

Metasploit 3.0 Developer's Guide



The Metasploit Staff
msfdev@metasploit.com

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Chapter 1

Introduction

The Metasploit framework is an open-source exploitation framework that is designed to provide security researchers and pen-testers with a uniform model for rapid development of exploits, payloads, encoders, NOP generators, and reconnaissance tools. The framework provides exploit writers with the ability to re-use large chunks of code that would otherwise have to be copied or re-implemented on a per-exploit basis. To help further this cause, the Metasploit staff is proud to present the next major evolution of the exploitation framework: version 3.0.

The 3.0 version of the framework is a re-factoring of the 2.x branch which has been written entirely in Ruby. The primary goal of the 3.0 branch is to make the framework easy to use and extend from a programmatic aspect. This goal encompasses not only the development of framework modules, such as exploits, but also to the development of third party tools and plugins that can be used to increase the functionality of the entire suite. By developing an easy to use framework at a programmatic level, it follows that exploits and other extensions should be easier to understand and implement than those provided in earlier versions of the framework.

This document will provide the reader with an explanation of the design goals, methodologies, and implementation details of the 3.0 version of the framework. Henceforth, the 3.0 version of the framework will simply be referred to as *the framework*.

1.1 Why Ruby?

During the development of the framework, the one recurring question that the Metasploit staff was continually asked was why Ruby was selected as the pro-

programming language. To avoid having to answer this question on an individual basis, the authors have opted for explaining their reasons in this document.

The Ruby programming language was selected over other choices, such as python, perl, and C++ for quite a few reasons. The first (and primary) reason that Ruby was selected was because it was a language that the Metasploit staff enjoyed writing in. After spending time analyzing other languages and factoring in past experiences, the Ruby programming language was found to offer both a simple and powerful approach to an interpreted language. The degree of introspection and the object-oriented aspects provided by Ruby were something that fit very nicely with some of the requirements of the framework. The framework's need for automated class construction for code re-use was a key factor in the decision making process, and it was one of the things that perl was not very well suited to offer. On top of this, the syntax is incredibly simplistic and provides the same level of language features that other more accepted languages have, like perl.

The second reason Ruby was selected was because of its platform independent support for threading. While a number of limitations have been encountered during the development of the framework under this model, the Metasploit staff has observed a marked performance and usability improvement over the 2.x branch. Future versions of Ruby (the 1.9 series) will back the existing threading API with native threads for the operating system the interpreter is compiled against which will solve a number of existing issues with the current implementation (such as permitting the use of blocking operations). In the meantime, the existing threading model has been found to be far superior when compared to a conventional forking model, especially on platforms that lack a native fork implementation like Windows.

Another reason that Ruby was selected was because of the supported existence of a native interpreter for the Windows platform. While perl has a cygwin version and an ActiveState version, both are plagued by usability problems. The fact that the Ruby interpreter can be compiled and executed natively on Windows drastically improves performance. Furthermore, the interpreter is also very small and can be easily modified in the event that there is a bug.

The Python programming language was also a language candidate. The reason the Metasploit staff opted for Ruby instead of python was for a few different reasons. The primary reason is a general distaste for some of the syntactical annoyances forced by python, such as block-indentation. While many would argue the benefits of such an approach, some members of the Metasploit staff find it to be an unnecessary restriction. Other issues with Python center around limitations in parent class method calling and backward compatibility of interpreters.

The C/C++ programming languages were also very seriously considered, but in the end it was obvious that attempting to deploy a portable and usable framework in a non-interpreted language was something that would not be feasible.

Furthermore, the development time-line for this language selection would most likely be much longer.

Even though the 2.x branch of the framework has been quite successful, the Metasploit staff encountered a number of limitations and annoyances with perl's object-oriented programming model, or lack thereof. The fact that the perl interpreter is part of the default install on many distributions is not something that the Metasploit staff felt was worth detouring the language selection. In the end, it all came down to selecting a language that was enjoyed by the people who contribute the most to the framework, and that language ended up being Ruby.

1.2 Design and Architecture

The framework was designed to be as modular as possible in order to encourage the re-use of code across various projects. The most fundamental piece of the architecture is the *Rex* library which is short for the **Ruby Extension Library**¹. Some of the components provided by Rex include a wrapper socket subsystem, implementations of protocol clients and servers, a logging subsystem, exploitation utility classes, and a number of other useful classes. Rex itself is designed to have no dependencies other than what comes with the default Ruby install. In the event that a Rex class depends on something that is not included in the default install, the failure to find such a dependency should not lead to an inability to use Rex.

The framework itself is broken down into a few different pieces, the most low-level being the *framework core*. The framework core is responsible for implementing all of the required interfaces that allow for interacting with exploit modules, sessions, and plugins. This core library is extended by the *framework base* library which is designed to provide simpler wrapper routines for dealing with the framework core as well as providing utility classes for dealing with different aspects of the framework, such as serializing module state to different output formats. Finally, the base library is extended by the *framework ui* which implements support for the different types of user interfaces to the framework itself, such as the command console and the web interface.

Separate from the framework itself are the modules and plugins that it's designed to support. A framework module is defined as being one of an exploit, payload, encoder, NOP generator, or recon tool. These modules have a well-defined structure and interface for being loaded into the framework. A framework plugin is very loosely defined as something that extends the functionality of the framework or augments an existing feature to make it act in a different manner. Plugins can add new commands to user interfaces, log all network

¹This library has many similarities to the 2.x Pex library

traffic, or perform whatever other action might be useful.

Figure 1.1 illustrates the framework's inter-package dependencies. The following sections will elaborate on each of the packages described above and the various important subsystems found within each package. Full documentation of the classes and APIs mentioned in this document can be found in the auto-generated API level documentation found on the Metasploit website.

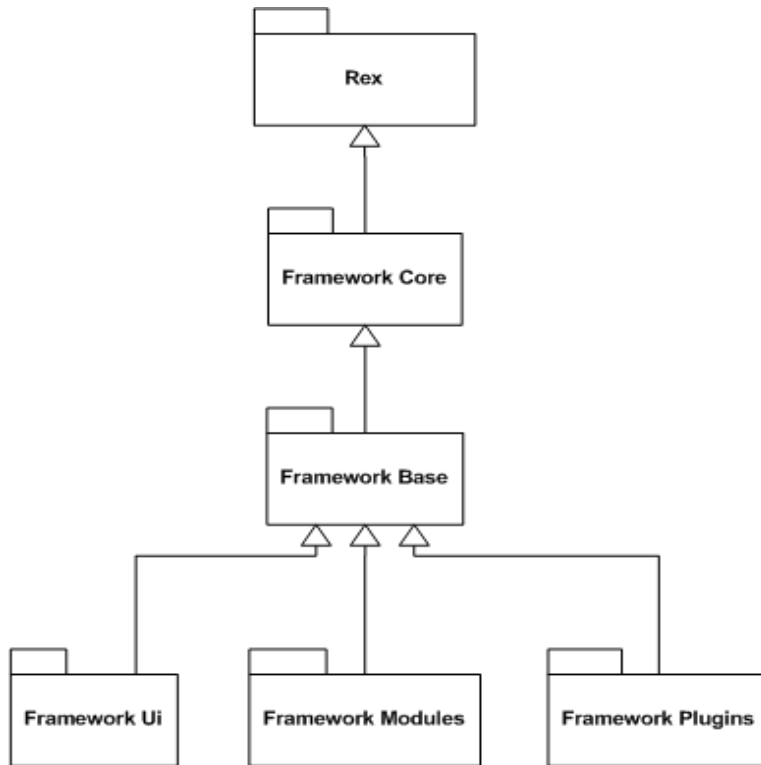


Figure 1.1: Framework 3.0 package dependencies

Chapter 2

Rex

The *Rex* library is a collection of classes and modules that may be useful to more than one project. The most useful classes provided by the library are documented in the following subsections. To use the Rex library, a ruby script should require `rex`.

2.1 Assembly

When writing exploits it is often necessary to generate assembly instructions on the fly with variable operands, such as immediate values, registers, and so on. To support this requirement, the Rex library provides classes under the `Rex::Arch` namespace that implement architecture-dependent opcode generation routines as well as other architecture-specific methods, like integer packing.

2.1.1 Integer packing

Packing an integer depends on the byte-ordering of the target architecture, whether it be big endian or little endian. The `Rex::Arch.pack_addr` method supports packing an integer using the supplied architecture type (`ARCH_XXX`) as an indication of which byte-ordering to use.

2.1.2 Stack pointer adjustment

Some exploits require the stack pointer be adjusted prior to the execution of a payload that modifies the stack in order to prevent corruption of the payload itself. To support this, the `Rex::Arch.adjust_stack_pointer` method provides

a way to generate the opcodes that lead to adjusting the stack pointer of a given architecture by the supplied adjustment value. The adjustment value can be positive or negative.

2.1.3 Architecture-specific opcode generation

Each architecture that currently has support for dynamically generating instruction opcodes has a class under the `Rex::Arch` namespace, such as `Rex::Arch::X86`. The X86 class has support for generating `jmp`, `call`, `push`, `mov`, `add`, and `sub` instructions.

2.2 Encoding

Encoding buffers using algorithms like XOR can sometimes be useful outside the context of an exploit. For that reason, the Rex library provides a basic set of classes that implement different types of XOR encoders, such as variable length key XOR encoders and additive feedback XOR encoders. These classes are used by the framework to implement different types of basic encoders that can be used by encoder modules. The classes for encoding buffers can be found in the `Rex::Encoding` namespace.

2.3 Exploitation

Often times vulnerabilities will share a common attack vector or will require a specific order of operations in order to achieve the end-goal of code execution. To assist in that matter, the Rex library has a set of classes that implement some of the common necessities that exploits may have.

2.3.1 Egghunter

In some cases the exploitation of a vulnerability may be limited by the amount of payload space that exists in the area of the overflow. This can sometimes prevent normal methods of exploitation from being possible due to the inability to fit a standard payload in the amount of room that is available. To solve this problem, an exploit writer can make use of an *egghunting* payload that searches the target process' address space for an egg that is prefixed to a larger payload. This requires that an attacker have the ability to stick the larger payload somewhere else in memory prior to exploitation. In the event that an egghunter is necessary, the `Rex::Exploitation::Egghunter` class can be used.

2.3.2 SEH record generation

One attack vector that is particularly common on the Windows platform is what is referred to as an SEH overwrite. When this occurs, an SEH registration record is overwritten on the stack with user-controlled data. To leverage this, the handler address of the registration record is pointed to an address that will either directly or indirectly lead to control of execution flow. To make this work, most attackers will point the handler address at the location of a `pop/pop/ret` instruction set somewhere in the address space. This action returns four bytes before the location of the handler address on the stack. In most cases, attackers will set two of the four bytes to be equivalent a short jump instruction that hops over the handler address and into the payload controlled by the attacker.

While the common approach works fine, there is plenty of room for improvement. The `Rex::Exploitation::Seh` class provides support for generating the normal (static) SEH registration record via the `generate_static_seh_record` method. However, it also supports the generation of a dynamic registration record that has a random short jump length and random padding between the end of the registration record and the actual payload. This can be used to make the exploit harder to signature in an IDS environment. The generation of a dynamic registration record is provided by `generate_dynamic_seh_record`. Both methods are wrapped by the `generate_seh_record` method that decides which of the two methods to use based on evasion levels.

2.4 Jobs

In some cases it is helpful to break certain tasks down into the concept of jobs. Jobs are simply defined as finite workitems that have a specific task. Using this definition, the Rex library provides a class named `Rex::JobContainer` that exposes an interface for coordinating various finite tasks in a centralized manner. New jobs can be added to the job container by calling the `add_job` method. Once added, a job can be started by issuing a call to the `start_job` method. At any time, a job can be stopped by calling the `stop_job` which will also remove the job by calling the `remove_job` method.

For more information about the usage of these API routines, please refer to the auto-generated documentation on Metasploit website.

2.5 Logging

The Rex library provides support for the basic logging of strings to arbitrary log sinks, such as a flat file or a database. The logging interface is exposed

to programmers through a set of globally-defined methods: `dlog`, `ilog`, `wlog`, `elog`, and `rlog`. These methods represent debug logging, information logging, warning logging, error logging, and raw logging respectively. Each method can be passed a log message, a log source (the name of the component or package that the message came from), and a log level which is a number between zero and three. Log sources can be registered on the fly by `register_log_source` and their log level can be set by `set_log_level`.

The log levels are meant to make it easy to hide verbose log messages when they are not necessary. The use of the three log levels is defined below:

2.5.1 LEV_0 - Default

This log level is the default log level if none is specified. It should be used when a log message should always be displayed when logging is enabled. Very few log messages should occur at this level aside from necessary information logging and error/warning logging. Debug logging at level zero is not advised.

2.5.2 LEV_1 - Extra

This log level should be used when extra information may be needed to understand the cause of an error or warning message or to get debugging information that might give clues as to why something is happening. This log level should be used only when information may be useful to understanding the behavior of something at a basic level. This log level should not be used in an exhaustively verbose fashion.

2.5.3 LEV_2 - Verbose

This log level should be used when verbose information may be needed to analyze the behavior of the framework. This should be the default log level for all detailed information not falling into LEV_0 or LEV_1. It is recommended that this log level be used by default if you are unsure.

2.5.4 LEV_3 - Insanity

This log level should contain very verbose information about the behavior of the framework, such as detailed information about variable states at certain phases including, but not limited to, loop iterations, function calls, and so on. This log level will rarely be displayed, but when it is the information provided should make it easy to analyze any problem.

2.6 Opcode Database

The rex library provides a class that makes it possible to interact with the Metasploit opcode database in a programmatic fashion. The class that provides this feature can be found in `Rex::Exploitation::OpcodeDb::Client`. To learn more about interacting with the opcode database using this interface, please refer to the auto-generated documentation on the Metasploit website.

2.7 Post-exploitation

The rex library provides client-side implementations for some advanced post-exploitation suites, such as DispatchNinja and Meterpreter. These two post-exploitation client interfaces are designed to be usable outside of the context of an exploit. The `Rex::Post` namespace provides a set of classes at its root that are meant to act as a generalized interface to remote systems via the post-exploitation clients, if supported. These classes allow programmers to write automated tools that can operate upon remote machines in a platform-independent manner. While it's true that platforms may lack analogous feature sets for some actions, the majority of the common set of actions will have functional equivalents.

2.8 Protocols

Support for some of the more common protocols, such as HTTP and SMB, is included in the rex library to help with the development of protocol-specific exploits and to allow for ease of use in other projects. Each protocol implementation exists under the `Rex::Proto` namespace.

2.8.1 DCERC

The rex library supports a fairly robust implementation of a portion of the DCERPC feature-set and includes support for doing evasive actions such as multi-context bind and packet fragmentation. The classes that support the DCERPC client interface can be found in the `Rex::Proto::DCERPC` namespace.

2.8.2 HTTP

Minimal support for an HTTP client and server is provided in the rex library. While similar protocol class implementations are provided both in webrick and

in other areas of the ruby default standard library set, it was deemed that the current implementations were not well suited for general purpose use due to the existence of blocking request parsing and other such things. The rex-provided HTTP library also provides classes for parsing HTTP requests and responses. The HTTP protocol classes can be found under the `Rex::Proto::Http` namespace.

2.8.3 SMB

Robust support for the SMB protocol is provided by the classes in the `Rex::Proto::SMB` namespace. These classes support connecting to SMB servers and performing logins as well as other SMB-exposed actions like transacting a named pipe and performing other specific commands. The SMB classes are particularly useful for exploits that require communicating with an SMB server.

2.9 Services

One of the limitations identified in the 2.x branch of the framework was that it was not possible to share listeners on the local machine when attempting to perform two different exploits that both needed to listen on the same port. To solve this problem, the 3.0 version of the framework provides the concept of *services* which are registered listeners that are initialized once and then subsequently shared by future requests to allocate the same service. This makes it possible to do things like have two exploits waiting for an HTTP request on port 80 without having any sort of specific conflicts. This is especially useful because it makes it possible to not have to worry about firewall restrictions on outbound ports that would normally only permit connections to port 80, thus making it possible to try multiple client-side exploits against a host with all the different exploit instances listening on the same port for requests.

Aside from the sharing of HTTP-like services, the service subsystem also provides a way to relay connections from a local TCP port to an already existing stream. This support is offered through the `Rex::Services::LocalRelay` class.

2.10 Sockets

One of the most important features of the rex library is the set of classes that wrapper sockets. The socket subsystem provides an interface for creating sockets of a given protocol using what is referred to as a `Comm` factory class. The purpose of the `Comm` factory class is to make the underlying transport and classes used to establish the connection for a given socket opaque. This makes it possible

for socket connections to be established using the local socket facilities as well as by using some sort of tunneled socket proxying system as is the case with Meterpreter connection pivoting.

Sockets are created using the socket `Parameter` class which is initialized either directly or through the use of a hash. The hash initialization of the `Parameter` class is much the same as perl's socket initialization. The hash attributes supported by the `Parameter` class are documented in the constructor of the `Parameter` class.

There are a few different ways to create sockets. The first way is to simply call `Rex::Socket.create` with a hash that will be used to create a socket of the appropriate type using the supplied or default `Comm` factory class. A second approach that can be used is to call the `Rex::Socket::create_param` method which takes an initialized `Parameter` instance as an argument. The remaining approaches involve using protocol-specific factory methods, such as `create_tcp`, `create_tcp_server`, and `create_udp`. All three of these methods take a hash as a parameter that is translated into a `Parameter` instance and passed on for actual creation.

All sockets have five major attributes that are shared in common, though some may not always be initialized. The first attributes provide information about the remote host and port and are exposed through the `peerhost` and `peerport` attributes, respectively. The second attributes provide information the local host and port and are exposed through the `localhost` and `localport` attributes, respectively. Finally, every socket has a hash of contextual information that was used during its creation which is exposed through the `context` attribute. While most exploits will have an empty hash, some exploits may have a hash that contains state information that can be used to track the originator of the socket. The framework makes use of this feature to associate sockets with framework, exploit, and payload instances.

2.10.1 Comm classes

The `Comm` interface used in the library has one simple method called `create` which takes a `Parameter` instance. The purpose of this factory approach is to provide a location and transport independent way of creating compatible socket object instances using a generalized factory method. For connections being established directly from the local box, the `Rex::Socket::Comm::Local` class is used. For connections be established through another machine, a medium specific `Comm` factory is used, such as the Meterpreter `Comm` class.

The `Comm` interface also supports registered event notification handlers for when certain things occur, like prior to and after the creation of a new socket. This can be used by external projects to augment the feature set of a socket or to change its default behavior.

2.10.2 TCP sockets

TCP sockets in the Rex library are implemented as a mixin, `Rex::Socket::Tcp`, that extends the built-in ruby `Socket` base class when the local `Comm` factory is used. This mixin also includes the `Rex::IO::Stream` and `Rex::Socket` mixins. For TCP servers, the `Rex::Socket::TcpServer` class should be used.

2.10.3 SSL sockets

SSL sockets are implemented on top of the normal Rex TCP socket mixin and makes use of the OpenSSL Ruby support. The module used for SSL TCP sockets is `Rex::Socket::SslTcp`.

2.10.4 Switch board routing table

One of the advancements in the 3.0 version of the framework is the concept of a local routing table that controls which `Comm` factory is used for a particular route. The reason this is useful is for scenarios where a box is compromised that straddles an internal network that can't be directly reached. By adjusting the switch board routing table to point the local subnet through a Meterpreter `Comm` running on the host that straddles the network, it is possible to force the socket library to automatically use the Meterpreter `Comm` factory when anything tries to communicate with hosts on the local subnet. This support is implemented through the `Rex::Socket::SwitchBoard` class.

2.10.5 Subnet walking

The `Rex::Socket::SubnetWalker` class provides a way of enumerating all the IP addresses in a subnet as described by a subnet address and a netmask.

2.11 Synchronization

Due to the use of multi-threading, the Rex library provides extra classes that don't exist by default in the Ruby standard library. These classes provide extra synchronization primitives.

2.11.1 Notification events

While Ruby does have the concept of a `ConditionVariable`, it lacks the complete concept of notification events. Notification events are used extensively on platforms like Windows. These events can be waited on and signaled, either permanently or temporarily. Please refer to Microsoft's online documentation for more information. This support is provided by the `Rex::Sync::Event` class.

2.11.2 Reader/Writer locks

A common threading primitive is the reader/writer lock. Reader/writer locks are used to make it possible for multiple threads to be reading a resource concurrently while only permitting exclusive access to one thread when write operations are necessary. This primitive is especially useful for resources that are not updated very often as it can drastically reduce lock contentions. While it may be overkill to have such a synchronization primitive in the library, it's still cool.

The reader/writer lock implementation is provided by the `Rex::ReadWriteLock` class. To lock the resource for read, the `lock_read` method can be used. To lock the resource for write access, the `lock_write` method can be used.

2.11.3 Reference counting

In some cases it is necessary to reference count an instance in a synchronized fashion so that it is not cleaned up or destroyed until the last reference is gone. For this purpose, the `Rex::Ref` class can be used with the `refinit` method for initializing references to 1 and the `ref` and `deref` methods that do what their names imply. When the reference count drops to zero, the `cleanup` method is called on the object instance to give it a chance to restore things back to normal in a manner similar to a destructor.

2.11.4 Thread-safe operations

Some of the built-in functions in Ruby are not thread safe in that they can block other ruby threads from being scheduled in certain conditions. To solve this problem, the functions that have issues have been wrapped with implementations that ensure that not all ruby threads will block. The specific methods that required change were `select` and `sleep`.

2.12 Ui

The Rex library provides a set of helper classes that may be useful to certain user interface mediums. These classes are not included by default when requiring `rex`, so a programmer must be sure to require `rex/ui` to get the classes described in this section. At the time of this writing, the only user interface medium that has any concrete classes defined is the `text`, which is synonymous with the console, user interface medium.

2.12.1 Text

The `text` user interface medium provides classes that allow a programmer to interact with a terminal's input and output handles. It also provides classes for simulating a pseudo-command shell in as robust a manner as possible.

Input

The `Rex::Ui::Text::Input` class acts as a base class for more specific user input mediums. The base class interface provides a basic set of methods for reading input from the user (`gets`), checking if standard input has closed (`eof?`), and others. There are currently two classes that extend the base class. The first is `Rex::Ui::Text::Input::Stdio`. This class simply makes use of the `$stdin` globally scoped variable in Ruby. This is the most basic form of acquiring user input. The second class is `Rex::Ui::Text::Input::Readline` which interacts with the user through the `readline` library. If no `readline` installation is present, the class will not be usable. These two classes can be used by the shell classes described later in this subsection.

Output

The `Rex::Ui::Text::Output` class implements the more generalized `Rex::Ui::Output` abstract interface. The purpose of the class is to define a set of functions that can be used to provide the user with output. There are currently two classes that implement the textual output interface. The first is `Rex::Ui::Text::Output::Buffer`. This output medium serializes printed text to a buffer that can be retrieved via the instance's `buf` attribute. The second class is `Rex::Ui::Text::Output::Stdio`. This class is the complement to the `stdio` input class and simply uses the `$stdout` global variable to supply the user's terminal with output.

Shell

The `Rex::Ui::Text::Shell` class provides a simple pseudo-shell base class that can be used to implement an interactive prompting shell with a user. The class is instantiated by passing a prompt string and a prompt character (which defaults to `>`) to the constructor. By default, the shell's input and output class instances are initialized to instances of the `Rex::Ui::Text::Input::Stdio` and `Rex::Ui::Text::Output::Stdio`, respectively. To change the input and output class instances, a call can be made to the `init_ui` method.

To use the shell, a call must be made to the shell instance's `run` method. This method accepts either a block context, which will be passed line-based input strings, or will operate in a callback mode where a call is made to the `run_single` method on the shell instance. If the second method is used, the class is intended to be overridden with a custom implementation of the `run_single` method.

Dispatcher Shell

The `Rex::Ui::Text::DispatcherShell` class extends the `Rex::Ui::Text::Shell` class by introducing the concept of a generalized command dispatcher interface. The dispatcher shell works by overriding the `run_single` method. Unlike the base shell class, the dispatcher shell provides a mechanism by which command dispatchers can be registered for processing input text in a normalized fashion. All command dispatchers should include the `Rex::Ui::Text::DispatcherShell::CommandDispatcher` mixin which provides a set of helper methods, mainly dealing without wrapping the output of text.

The registration of a command dispatcher is accomplished by calling either `enstack_dispatcher` or `append_dispatcher`. The `enstack_dispatcher` front inserts the supplied command dispatcher instance so that it will have the first opportunity to process commands. The `append_dispatcher` method inserts the supplied command dispatcher instance at the end of the list. To remove command dispatchers, the complementary methods `destack_dispatcher` and `remove_dispatcher` can be used.

When a line of input arrives, the base shell class calls the overridden `run_single` method which breaks the input string down into an array of arguments as delimited by normal shell characters. The first argument in the string is then evaluated in relation to all of the registered command dispatchers by checking to see if any of them implement a method called `cmd_<arg 0>`. If they do, the dispatcher shell calls the method and passes it the parsed argument array.

In order to make it possible to automatically generate a help menu for all registered command dispatchers, each command dispatcher should implement a method named `commands` which should return a hash that associates commands with a description of the operation they perform.

Table

The `Rex::Ui::Text::Table` class can be used to format data in the form of a table with a header, columns, and rows. For more information on using the table class, please refer to the auto-generated API documentation on the Metasploit website.

Subscribers

The Rex library supports creating classes that are designed to subscribe to input and output interfaces via the `Rex::Ui::Subscriber` interface. This mixin provides a method called `init_ui` which can be passed an input and output class instance. These instances should implement the `Rex::Ui::Text::Input` and `Rex::Ui::Output` interfaces, respectively. Once `init_ui` has been called, subsequent calls to methods like `print_line` will be passed down into the initialized output class instance. If no class instance has been defined, the call will be ignored. This makes it possible to provide a way by which classes can interact with the user interface only when desired. To disable user interface interaction, a call can be made to `reset_ui` which will disable future input and output classes for the class.

Chapter 3

Framework Core

The framework core implements the set of classes that provide an interface to framework modules and plugins. The core portion of the framework is designed by used in an instance-based approach. This means that the entire framework state can be contained within one class instance thereby allowing programmers to have multiple concurrent and separate framework instances in use at the same time rather than forcing everything to share one singleton instance.

The current major version of the framework core can be accessed through `Msf::Framework::Major` and the minor version can be accessed through `Msf::Framework::Minor`. A combined version of these two version numbers can be accessed through `Msf::Framework::Version` or `framework.version` on an instance level. The current revision of the framework core interface can be accessed through `Msf::Framework::Revision`.

The framework core is accessed through an instance of the `Msf::Framework` class. Creating an instance of the framework is illustrated in figure 3.1.

```
framework = Msf::Framework.new
```

Figure 3.1: Creating an instance of the framework

The framework instance itself is nothing more than a way of connecting the different critical subsystems of the framework core, such as module management, session management, event dispatching, and so on. The manner of using these subsystems will be described in the following subsections. To use the framework core library, a ruby script should require `msf/core`.

3.1 DataStore

Each framework instance has an instance of the `Msf::DataStore` class that can be accessed via `framework.datastore`. The purpose of the datastore in the 3.0 version of the framework is to act as a replacement for the concept of the environment in the 2.x branch. The datastore is simply a hash of values that may be used either by modules or by the framework itself to reference programmer or user controlled values. Interacting with the datastore is illustrated in figure 3.2.

```
framework.datastore['foo'] = 'bar'

if (framework.datastore['foo'] == 'bar')
  puts "'foo' is 'bar'"
end
```

Figure 3.2: Creating an instance of the framework

Modules will inherit values from the framework's global datastore if they are not found in the module's localized datastore. This aspect will be discussed in more detail in chapter 6.

3.2 Event Notifications

One of the major goals with the 3.0 version of the framework was to provide developers with a useful event notification system that would allow them to perform arbitrary actions when certain framework events occurred. To support this, each framework instance can have event handlers registered through the `framework.events` attribute which is an instance of the `Msf::EventDispatcher` class.

The `EventDispatcher` class supports registering event handlers for a few basic different categories. These categories will be discussed individually. One of the nice aspects of the event-driven framework is that modules can automatically indicate their interest in being registered for event handler notifications by simply implementing the event subscriber mixins described below. When a module is loaded into the framework, it will automatically detect that it includes one or more of the subscriber interfaces and automatically register the module with the appropriate event notifiers. This makes it possible for modules to take certain actions when specific events occur.

3.2.1 Exploit events

Event subscribers can be registered to be notified when events regarding exploitation occur. To register an exploit event subscriber, a call should be made to `framework.events.register_exploit_subscriber`. This method should be passed an instance of an object that includes the `Msf::ExploitEvent` mixin. The type of event that this subscriber will be notified of is when an exploit succeeds. In the event that an exploit succeeds, the subscriber's `on_exploit_success` method will be called with the exploit instance that succeeded and the session instance that it created.

To remove an event subscriber, a call should be made to `framework.events.remove_exploit_subscriber` passing the object instance that was used to add the subscriber in the first place.

3.2.2 General framework events

To receive event notifications about internal framework events, a general event subscriber can be registered through the `framework.events.register_general_subscriber` method. This method takes an instance of an object that includes the `Msf::GeneralEventSubscriber` mixin. When a module is loaded into the framework instance, the `on_module_load_proc` will be called if it is non-nil and will be passed the reference name and class associated with the newly loaded module. When a module instance is created, the `on_module_created_proc` will be called if it's non-nil and will be passed the newly created module instance.

To remove an event subscriber, a call should be made to `framework.events.remove_general_subscriber` passing the object instance that was used to add the subscriber in the first place.

3.2.3 Recon events

To receive notifications about reconnaissance events, such as when a new host or service is detected, a recon event subscriber can be registered through the `framework.events.add_recon_subscriber` method. This method takes an instance of an object that implements one or both of the `Msf::ReconEvent::HostSubscriber` or `Msf::ReconEvent::ServiceSubscriber` mixins. When a new host is detected or an attribute of a host has changed, a call will be made to the event subscriber's `on_host_changed` method assuming it implements the `Msf::ReconEvent::HostSubscriber` mixin. When a new service is detected or an attribute of a service has changed, a call will be made to the event subscriber's `on_service_changed` method assuming it implements the `Msf::ReconEvent::ServiceSubscriber` mixin.

To remove an event subscriber, a call should be made to

`framework.events.remove_recon_subscriber` passing the object instance that was used to add the subscriber in the first place.

3.2.4 Session events

To receive notifications about events pertaining to sessions, a session event subscriber can be registered through the `framework.events.add_session_subscriber` method. This method takes an instance of an object that implements the `Msf::SessionEvent` mixin. When a new session is opened, the framework will call into the subscriber's `on_session_open` method with the session instance that has just been opened as the first argument. When a session terminates, the framework will call into the subscriber's `on_session_close` method with the session instance that is being closed.

To remove an event subscriber, a call should be made to `framework.events.remove_session_subscriber` passing the object instance that was used to add the subscriber in the first place.

3.3 Framework Managers

The framework core itself is composed of a few different managers that are responsible for some of the basic aspects of the framework, such as module and plugin management.

3.3.1 Module management

The module management aspect of the framework is one of its most integral parts. The `Msf::ModuleManager` class is responsible for providing the interface for loading modules and for acting as a factory for module instance creation. The module manager itself can be accessed through the `framework.modules` attribute. The loading of modules is accomplished by adding a search path to the module manager by making a call to the `add_module_path` method. This method will automatically load all of the modules found within the supplied directory¹.

Modules are symbolically identified by what is referred to as a *reference name*. The reference name takes a form that is similar to a directory path and is partially controlled by the filesystem path that the module is loaded from. An example of a reference name would be an exploit labeled `windows/ftp/wsftpd`.

¹The module path must conform to the standard module directory layout, with the base directory structure appearing similar to the `modules` sub-directory in the framework distribution

This would mean that the exploit was loaded from `exploits/windows/ftp/wsftpd.rb`. It is important to note that module's must retain a namespace hierarchy that mirrors the path in which they are located. For instance, the example described previously would have the class declared as `Msf::Exploits::Windows::Ftp::Wsftpd`. This is necessary so that the framework's module manager knows what namespace to look in to see what class was added after loading the file. The reference name of a module can be accessed through the `refname` attribute on both the class of the module and its instances.

In order to help solve the potential for module name ambiguities across module types, modules can also be referenced to by what is called a *full reference name*. This name is the same as the reference name of the module but is prefixed with the module's type. For instance, the exploit `windows/ftp/wsftpd` would become `exploit/windows/ftp/wsftpd`. The full reference named can be accessed through the `fullname` attribute on both the class of the module and its instances.

In order to make the module manager easy to use, each different module type is broken down into a more basic class called a module set which is implemented by the `Msf::ModuleSet` class. The purpose of a module set is to act as a localized factory for each different module type (exploit, encoder, nop, etc). Each type-specific module set can be accessed through either `framework.type` or `framework.modules.type`. For example, if one wanted to enumerate exploit modules, they would use the `framework.exploits` method to get access to the exploit module set.

Module sets are implemented in the form of a hash that associates the reference names of modules with their underlying classes. To create an instance of a module, a call is made to the module set's `create` method passing the reference name of the module that should be instantiated. For example, to create an instance of an exploit named `windows/ftp/wsftpd`, a call would be made as shown in figure 3.3

```
framework.exploits.create('windows/ftp/wsftpd')
```

Figure 3.3: Creating an instance of a framework module

The table shown in figure 3.4 shows the relation between module types and framework module set accessors.

To reload the contents of a module, a call can be issued to `reload_module` passing the module instance that should be reloaded. This will lead to the framework re-reading the contents of the module's underlying file path and automatically creating a new instance of the module.

Module Type	Accessor
MODULE_ENCODER	framework.encoders
MODULE_EXPLOIT	framework.exploits
MODULE_NOP	framework.nops
MODULE_RECON	framework.recon
MODULE_PAYLOAD	framework.payloads

Figure 3.4: Module types and their framework accessors

3.3.2 Plugin management

One of the new features in the 3.0 version of the framework is the concept of framework plugins. Unlike modules, framework plugins are meant to add features to the framework or to change the behavior of existing aspects of the framework. Plugins have a very loose definition in terms of the scope in which they can operate. For instance, a plugin could add an entirely new module type for use by the framework. Alternatively, a plugin could add commands to the existing user interfaces that interact with the framework. A plugin could also register custom event subscribers for doing things like automatically causing Meterpreter to list the contents of a computer's C drive when a new Meterpreter session is created. The possibilities, as they say, are endless.

The plugin manager can be accessed through the `framework.plugins` accessor which is an instance of the `Msf::PluginManager` class. To load a plugin, a call can be made to `framework.plugins.load` with the path of the plugin that is to be loaded. Optionally, a second parameter can be passed to the `load` method that is a hash of option parameters that may be useful to the plugin, such as `LocalInput` and `LocalOutput` handles for use with printing strings to the screen for whatever medium is currently being used. The table shown in figure 3.5 shows the pre-defined hash elements that can be passed in the option hash.

Hash Element	Description
LocalInput	The local input class instance which implements the <code>Rex::Ui::Text::Input</code> interface.
LocalOutput	The local output class instance which implements the <code>Rex::Ui::Output</code> interface.
ConsoleDriver	The console driver instance of <code>Msf::Ui::Console::Driver</code> .
WebDriver	The console driver instance of <code>Msf::Ui::Web::Driver</code> .

Figure 3.5: Plugin optional constructor hash elements

All plugins are reference counted. This is to make it possible to implement

singleton plugins that could possibly be loaded more than once but will only have one underlying instance. The reference count to an instance of a plugin is automatically incremented each time `load` is called on it.

To unload a framework plugin, a call can be made to `framework.plugins.unload` passing the instance of the plugin previously loaded as the first parameter. Since all plugins are reference counted, a plugin will not actually be unloaded until its reference count drops to zero.

For more detail on the implementation of framework plugins, please see chapter 7.

3.3.3 Recon management

The reconnaissance manager is used to provide an interface for reporting information about hosts, services, and other reconnaissance entities. These reports are tracked internally by the recon manager which is implemented by the `Msf::ReconManager` class. The recon manager can be accessed through the `framework.reconmgr` accessor.

This area of the framework is currently undergoing design review and therefore does not have any documentation at this time.

3.3.4 Session management

The session manager is used to track sessions created from within a framework instance as the result of an exploit succeeding. The purpose of sessions is to expose features to a programmer that allow it to be interacted with. For instance, a command shell session allows programmers to send commands and read responses to those commands through a well-defined API. For more information on sessions and how they can be interacted with, please see chapter 8. The session manager itself can be accessed through the `framework.sessions` accessor and is an instance of the `Msf::SessionManager` class.

The primary purpose of the session manager is to provide an interface for registering new sessions and assigning them a unique session identifier as well as allowing sessions to be deregistered when they are destroyed. The registering of sessions with the framework session manager is accomplished by making a call into the `framework.sessions.register` method which takes an instance of a session as its argument. This method will assign the session a unique session identifier and add it to the managed hash of sessions. Sessions can be enumerated by making a call into `framework.sessions.each_sorted` or by calling any of the hash-compatible enumeration methods. To obtain the session instance associated with a particular session identifier, the `framework.sessions.get` method can be called with the session identifier to look up. When a session

is being destroyed, a call must be made to `framework.sessions.deregister` passing the instance of the session being destroyed as the first argument.

3.3.5 Job management

Each framework instance supports running various tasks in the context of worker threads through the concept of jobs. The job interface can be accessed through the `framework.jobs` accessor which is an instance of the `Rex::JobContainer` class. For more information on jobs, please refer to the job explanation in the Rex documentation in section 2.4.

3.4 Utility Classes

Some classes in the framework core are intended to be used to make certain tasks simpler without being out of scope of the core aspects of the framework. These classes are described below.

3.4.1 Exploit driver

The `Msf::ExploitDriver` class encapsulates the task of running an exploit module in terms of coordinating the validation of required module options, the validation of target selection, the generation of a selected payload, and the execution of exploit and payload setup and cleanup. These operations are what has to be performed when attempting to execute an exploit.

An instance of an exploit driver is initialized as described in figure 3.7.

```
driver = Msf::ExploitDriver.new(framework)

driver.payload = payload_instance
driver.exploit = exploit_instance
driver.target_idx = 0

session = driver.run
```

Figure 3.6: Using the ExploitDriver class

When the `run` method is called, the first step is to validate the options required by the payload and the exploit that have been selected. This is done by calling the public `validate` method on the exploit driver instance. In the event that options fail to validate or that a target index has not been properly selected, an

exception will be thrown to the caller. After validation has completed, the exploit's `TARGET` data store element is set to the selected target index. From there, an encoded version of the payload is generated by calling `generate_payload` on the exploit instance. Once completed, the exploit is set up by calling `setup` on the exploit module instance and finally the actual exploit code is triggered by calling `exploit` on the exploit module instance.

Once exploitation has completed, the exploit driver calls the `stop_handler` method on the payload module instance and then calls the `cleanup` method on the exploit module instance.

The exploit driver can also be instructed to run the exploit in the context of a job. When this is done, the underlying exploitation operation is done in the context of a job worker thread by calling `framework.jobs.start_bj_job`. The exploit driver can be told to use a job by setting the `use_job` attribute to true.

3.4.2 Encoded payload

The purpose of the `Msf::EncodedPayload` class is to encapsulate the operation of encoding a payload with an arbitrary set of requirements. To generate an encoded payload, an instance of an `Msf::EncodedPayload` class must be created by passing its constructor an instance of a payload as well as an optional hash of requirements that will be used during the generation phase. This can be accomplished by calling the class' `create` method as shown in figure ??.

```
encoded = Msf::EncodedPayload.create(payload_instance,
  'BadChars'      => "\x0a\x0d",
  'Space'         => 400,
  'Prepend'       => "\x41\x41",
  'Append'        => "\xcc\xcc",
  'SaveRegisters' => "edi",
  'MinNops'       => 16)
```

Figure 3.7: Creating an instance of an EncodedPayload

Once an encoded payload instance has been created, the next step is to make a call to the instance's `generate` method which will return the encoded version of the payload. After generation has occurred, the following attributes can be accessed on the encoded payload instance in order to get information about the now-encoded payload. Figure 3.8 shows the attributes and their purposes.

To control the behavior of the encoded payload class, an optional hash can be passed into the constructor. The table in figure 3.9 describes the options that can be specified and the affect they have on behavior.

Attribute	Description
raw	The un-encoded raw payload buffer.
encoded	The encoded payload buffer which may be equal to raw if no encoder was used.
nop_sled_size	The size of the NOP sled prepended to the encoded payload. Zero if no NOPs were generated.
nop_sled	The NOP sled portion of the encoded payload, if any.
encoder	The encoder module instance that was used to encode the payload.
nop	The nop module instance that was used to generate the NOP sled, if any.

Figure 3.8: `Msf::EncodedPayload` instance attributes

Hash Element	Description
BadChars	A string of bad characters to avoid when encoding.
Encoder	The name of the preferred encoder to use.
MinNops	The minimum number of NOPs to generate.
MaxNops	The maximum number of NOPs to generate.
Space	The amount of room left for use by the payload. If this value is not specified, then NOP padding will not be performed and there will be no restrictions on payload size.
SaveRegisters	A white-space separated list of registers to save when generating the NOP sled.
Prepend	Raw instructions or text to prepend to the encoded payload.
Append	Raw instructions or text to append to the encoded payload.

Figure 3.9: `Msf::EncodedPayload` constructor options

Chapter 4

Framework Base

The framework base is a library layer built on top of the framework core that adds classes that make dealing with the framework easier. It also provides a set of classes that could be useful to third party development tools that don't necessarily fit within the scope of the framework core itself. The classes that compose the framework base are described in the following subsections. To use the framework base library, a ruby script should require `msf/base`.

4.1 Configuration

One important aspect of a managed framework installation is the concept of persistent configuration and methods for getting information about the structure of an installation, such as the root directory of the installation and other types of attributes. To facilitate this, the framework base library provides the `Msf::Config` class that has methods for obtaining various installation directory paths. It also supports the serialization of configuration files. The table shown in figure 4.1 describes the different methods that can be used to obtain configuration information.

4.2 Logging

The framework base library provides a wrapper class that can be used to control debug logging at an administrative level by providing methods for enabling log sources and for controlling logs that are applied to sessions created from within a framework instance. To initialize logging, a call must be made to `Msf::Logging.init` which will register the log sources `rex`, `core`, and `base` as

Method	Description
install_root	The installation's root directory.
config_directory	The configuration directory (<code>~/msf3</code>).
module_directory	<code>install_root + '/modules'</code> .
plugin_directory	<code>install_root + '/plugins'</code> .
log_directory	<code>config_directory + '/logs'</code> .
session_log_directory	<code>config_directory + '/logs/sessions'</code> .
user_module_directory	<code>config_directory + '/modules'</code> .
data_directory	<code>install_root + '/data'</code> .
config_file	<code>config_directory + '/config'</code> .
load	Loads the contents of a configuration file and returns an instance of a <code>Rex::Parser::Ini</code> object.
save	Saves the supplied option hash to the configuration file supplied as <code>'ConfigFile'</code> in the options hash or the <code>config_file</code> by default.

Figure 4.1: `Msf::Config` accessor methods

being directed at `framework.log` as found in the `Msf::Config.log_directory`. Individual log sources can be subsequently enabled or disabled by making calls to `Msf::Logging.enable_log_source` and `Msf::Logging.disable_log_source`, respectively. When session logging is enabled, calls can be issued to `start_session_log` and `stop_session_log` which operate on a provided session instance to start or stop logging to a session-specific log file in the `Msf::Config.session_log_directory` directory.

4.3 Serialization

To make life easier for framework programmers, the framework base library provides a class that can be used to serialize information about modules, such as their description, options, and other information to a uniform, human readable format. The class that provides this feature is the `Msf::Serializer::ReadableText` class. For more information, please review the auto-generated API documentation on the Metasploit website.

4.4 Sessions

While the framework core has an abstract concept of sessions as described through the `Msf::Session` base module, the framework base actually provides some of the concrete implementations. This separation was done to eliminate

module-specific session implementations from the framework core as the core should have no conceptual dependencies on modules that use it. The base library, on the other hand, is more of a facilitation layer for subscribers of the framework. The two sessions currently implemented in the base library are the `CommandShell` session and the `Meterpreter` session.

4.4.1 CommandShell

The command shell session implements the framework core `Msf::Session::Provider::SingleCommandShell` interface against a connected stream, such as a TCP connection. For more information about this mixin, please read chapter 8.

4.4.2 Meterpreter

The meterpreter session implements the `Msf::Session::Interactive` and `Msf::Session::Comm` mixins. This allows it to be operated through an interactive user shell and also indicates to the framework that internet traffic can be routed (pivoted) through the session by making use of it as a `Comm` socket factory. The session itself is merely an extension of the `Rex::Post::Meterpreter` class which operates against a connected stream, such as a TCP connection.

4.5 Simplified Framework

The simplified framework provides methods that make the framework and the different module types easier to use by providing wrapper methods that handle most of the actions that would be common to a subscriber of the framework. To create an instance of the simplified framework, the `Msf::Simple::Framework.create` method should be called along with an optional hash. The return value is an instance of an `Msf::Framework` class that has been extended by the `Msf::Simple::Framework` mixin. Existing framework instances can also be simplified by calling the `Msf::Simple::Framework.simplify` method with the existing framework instance as the first argument. All module instances created from within a simplified framework instance will automatically be simplified by the module type-specific mixins.

The creation of a simplified framework instance automatically leads to the initialization of the `Msf::Config` class and the `Msf::Logging` class. Any existing configuration file is also automatically loaded. The default global module directory (`Msf::Config::module_directory`) and the user-specific module directory (`Msf::Config::user_module_directory`) are added as search paths to the framework instance which leads to the loading of all modules within the two

directories. Finally, a general event subscriber is registered with the framework instance that will be called whenever module instances are created within the framework. This allows the simplified framework the opportunity to simplify each created module instance.

Each module type has a simplified framework module mixin that is automatically used to extend created module instances via the general event subscriber described above. For example, when an exploit module instance is created, the instance is extended by the `Msf::Simple::Exploit` mixin. Each different module mixin provides a helper method or methods for driving that specific module type's primary action or actions. Furthermore, each module instance has methods that can be used to save and restore module-specific configuration elements through the `save_config` and `load_config` methods. Each module-specific mixin is described individually below.

4.5.1 Exploit

The simplified exploit mixin provided in `Msf::Simple::Exploit` extends each exploit module instance with a method called `exploit_simple`. This method takes a hash parameter that is used to control the exploitation of something by creating an instance of an `Msf::ExploitDriver` class and doing all the required initialization and configuration of the module prior to issuing the call to the exploit driver's `run` method. If the operation succeeds, the return value is a session instance. Otherwise, an exception will be thrown or `nil` may be returned. For more information about the hash elements that can be passed in, please refer to the auto-generated API documentation on the Metasploit website.

4.5.2 NOP

The simplified NOP mixin provided in `Msf::Simple::Nop` extends each nop module instance with a method called `generate_simple`. This method takes the length of the sled generate and the hash of options that should be used for the generation. On success, the return value is a buffer that is encoded using the `Msf::Simple::Buffer` class using the format specified in the option hash as the `'Format'` element. If no format is specified, the raw version of the NOP sled is returned.

4.5.3 Payload

The simplified payload mixin provided in `Msf::Simple::Payload` extends each payload module instance with a method called `generate_simple`. This method

takes a hash of options that are used to generate a payload buffer. The elements that can be used in the option hash can be found in the auto-generated API documentation found on the Metasploit website. If the operation is successful, the encoded payload buffer will be serialized to the format supplied in the 'Format' hash element. If the format is not raw, any staged payloads will also be appended to the serialized buffer.

4.5.4 Recon

The reconnaissance interface is under design review.

Chapter 5

Framework Ui

The framework user interface library is used to encapsulate code common to different user interface mediums to allow third party development and extension of custom user interfaces separate from those distributed with the framework itself. Each different user interface medium is encapsulated in an abstract *driver* class, `Msf::Ui::Driver` that is designed to have an actual interface that is specific to the underlying user interface medium being used.

The inherited driver base class simply defines three methods that are to be common to all user interfaces. Those methods are `run`, `stop`, and `cleanup`. Their names imply the actions that are to be performed. Each of the currently defined user interface mediums will be explained individually in the following sections. To use the framework ui library, a ruby script should require `msf/ui`.

Chapter 6

Framework Modules

The primary purpose of the Metasploit framework is to facilitate the development of modules that can plug into the framework core and be shared with other existing modules. For instance, an advanced encoder module can be plugged into the framework and will be automatically applied to payloads of a compatible architecture and platform. This makes it so there are zero code changes required due to the fact that all modules conform to a well-defined interface through which they can be interacted with by the framework. As another example, new payloads can be developed and are immediately usable to all exploits without modification. This eliminates the need to copy static payload blobs into exploits as is most common with proof of concept exploits. This chapter is dedicated to describing the interfaces that each module type exposes in order to provide an understanding of what it takes to implement each module type.

At some level, all modules inherit from the module base class provided in `Msf::Module`. This class implements all of the things that are common to Metasploit framework modules, such as common accessors and attributes. When a module is loaded into the framework, a copy of the class that gets added is made which is what is used for future instantiations of the module. The copy class then has some of its attributes set that allow the framework to look at some of the module's information at a glance without having to create an instance of it. This information can be accessed through a set of class methods and attributes that are described in figure 6.1.

To support generic initialization, each module defines its own custom information hash that is eventually passed to the constructor of `Msf::Module`. This information class is then assigned to the instance attribute named `module_info` and is then processed. The parts that are common to all modules are broken down and transformed into uniform types that can be accessed through instance methods. The same methods that are accessible through the module class can

Method	Description
framework	The framework instance that the module is associated with.
type	The module's symbolic type. One of <code>MODULE_ENCODER</code> , <code>MODULE_EXPLOIT</code> , <code>MODULE_NOP</code> , <code>MODULE_PAYLOAD</code> , or <code>MODULE_RECON</code>
fullname	The complete symbolic name of the module including its string type. For example: <code>exploit/windows/ms03_026</code>
rank	The module's integer rank to indicate its quality. The rank is used by the framework when selecting which encoders, payloads, and NOP generators to use.
rank_to_s	Returns the string representation of the module's rank.
refname	The module's symbolic reference name. For example: <code>windows/ms03_026</code>
orig_cls	The original, non-duplicated class that was loaded for the module.
file_path	The file path that the module was loaded from.

Figure 6.1: `Msf::Module` class methods

also be used through the class instance (as shown in figure 6.1).

The table in figure 6.2 shows how the common module information hash elements are broken down into their respective data types and the methods that can be used to access them.

Some of the information hash accessors also have helper methods that make it easier to interact with them. For instance, the `Arch` hash element array contained within the `arch` attribute can be serialized to a comma separated string by calling `arch_to_s`. Architectures can also be enumerated by calling `each_arch` by passing it a block that accepts the architecture as a parameter. It is also possible to check if a module supports an architecture by calling the `arch?` method and passing it the architecture to check for as a parameter. Like architectures, platforms can be serialized to a string by calling `platform_to_s`.

The `Author` hash element can also be converted to a comma separated string of authors by calling `author_to_s`. The array of `Msf::Author` instances contained within the `author` array attribute can be enumerated by calling `each_author` and passing it a block that takes an author instance as its first parameter.

The `Msf::Module` class also has some helper methods that allow users to quickly check if a module is of a specific type by calling the `<type>?` method set. For instance, if a caller wished to see if a module instance was an exploit, they could call `mod.exploit?`.

Since the Rex library introduces the concept of socket communication facto-

Hash Element	Accessor	Type	Description
Name	name	String	The short name of the module.
Alias	alias	String	An alias string for the refname of the module.
Description	description	String	A longer description of the module.
Version	version	String	The current revision of the derived module.
License	license	String	The license that the module has been released under.
Author	author	Array	An array of <code>Msf::Author</code> instances.
Arch	arch	Array	An array of architectures (like <code>ARCH_X86</code>).
Platform	platform	PlatformList	An instance of a <code>Msf::PlatformList</code> .
References	references	Array	An array of <code>Msf::Reference</code> instances.
Options	options	OptionContainer	Options conveyed in the hash are added to the module's option container.
AdvancedOptions	options	OptionContainer	Options conveyed in the hash are added to the module's option container as advanced options.
DefaultOptions	options	OptionContainer	Previously registered options have their default value modified.
Privileged	privileged	Bool	Whether or not the module requires or grants privileged access.
Compat	compat	Hash	A hash of compatibility flags.

Figure 6.2: `Msf::Module` information hash accessors

ries (through the `Comm` class), each module has an attribute that can return the `Comm` instance that was used or preferred. By default, all modules return `Rex::Socket::Comm::Local`.

Each module has its own instance-based datastore which is an instance of the `Msf::ModuleDataStore` class and can be accessed through the `datastore` accessor. This mirrors the functionality provided by the global framework datastore in that it provides a localized variable to value association for use in satisfying required options. For instance, if a module requires the `RHOST` option to be set to a value, the module's data store must have a hash entry for `RHOST`. Alternatively, modules are designed to be able to fall back on the framework global datastore if their localized datastore does not have a value for a variable being checked for. This provides a basic level of variable/value inheritance. In some cases, modules may wish to share their localized copies of the datastore with other modules without having to taint the global datastore. This can be accomplished by calling the `share_datastore` method on a module instance and passing it a data store instance as the first argument.

Finally, framework modules are designed to be able to indicate their relative compatibilities with other modules. For instance, an exploit may wish to indicate that it is incompatible with a specific class of payload connection mediums. This is accomplished through the `Compat` information hash element. After the compatibility layer has been initialized, calls can be made to a module's `compatible?` method by passing another module instance as the argument. If the supplied module instance is compatible with the instance that's being checked against, then `true` is returned.

This basic interface provides a generalized view into the behavior and expectations of framework modules. However, all module types have well-defined interfaces for dealing with the actions that they are meant to undertake. These specific interfaces will be described in the following sections.

6.1 Encoder

Encoder modules are used to generate transformed versions of raw payloads in a way that allows them to be restored to their original form at execution time and then subsequently executed. To accomplish this, most encoders will take the raw form of the payload and run it through some kind of encoding algorithm, like bitwise XOR. After the encoded version is generated, a decoding stub is prefixed to the encoded version of the payload. This stub is responsible for performing the inverse operation on the buffer attached to the decoder when it executes. After the decoder restores the payload to its original form, it will transfer execution to the start of the now normalized payload.

To support the above described encoder model, the Metasploit framework pro-

vides the `Msf::Encoder` class which inherits from the `Msf::Module` base class. All encoders must inherit from the `Msf::Encoder` class at some level to ensure that encoder-specific methods are included in the derived class.

Like the module information hash, encoders have some specialized information hash elements that describe information about the encoder being used. The information that encoder modules need to describe are the attributes of the decoder which is conveyed through the `Decoder` information hash element. The `Decoder` hash element references another hash that contains decoder specific properties. These are described in the table shown in figure 6.3 along with their types and module instance accessors.

Hash Element	Accessor	Type	Description
Stub	<code>decoder_stub</code>	String	The raw stub to be prefixed to encoded payloads.
KeyOffset	<code>decoder_key_offset</code>	Fixnum	The offset to the key in the decoder stub.
KeySize	<code>decoder_key_size</code>	Fixnum	The size of the decoder key in bytes.
BlockSize	<code>decoder_block_size</code>	Fixnum	The size of each encoding block in bytes.
KeyPack	<code>decoder_key_pack</code>	String	The byte-ordering to use when packing the key. The default is 'V'.

Figure 6.3: `Msf::Encoder` Decoder information hash accessors

Each of the methods described in figure 6.3 are designed to be overridable so that derived encoder classes can dynamically choose the values returned by them rather than being forced to initialize them in a static hash element. The decoder hash itself can be accessed through the `decoder_hash` method in case an encoder module wishes to convey non-standard information in the hash for later reference.

Perhaps of more importance that the decoder initialization vector is how the encoding process is exposed. The base class `Msf::Encoder` implements an instance method named `encode` which takes a buffer as the first argument, a string of bad characters (or nil) as the second argument, and an optional encoder state as the third argument. The `encode` method wraps the encoding process in terms of selecting a decoder key, initializing the encoder state, and then performing the actual encoding operation. Once completed, the encoded buffer is returned to the caller. This is the primary method that the framework uses when interacting with framework encoder modules.

6.1.1 encode

At a more detailed level, the `encode` method first creates an instance of a `Msf::EncoderState` class if one was not supplied as the third argument of `encode`. The purpose of the encoder state is to contain transient information about a specific encoding operation in a non-global fashion. After creating the encoder state instance, `encode` prepends any encoder-specific data to the raw payload that may be necessary through the use of the `prepend_buf` instance method on the encoder module. This method is intended to be overridden and used as necessary. By default, an empty string is returned, effectively leaving the buffer in the same state that it was when it was passed in.

After prepending the raw buffer as necessary, the `encode` method then selects a decoder key if the `decoder_key_size` method returns a non-zero value and the encoder state currently has a `nil` key. This is accomplished by calling the `find_key` method on the encoder module which has a default implementation that is intended to work across all encoder modules. Once a key has been selected, the `init_key` method is called on the encoder state object to set the `state.key` and `state.orig_key` attributes. If no key is found, a `Msf::NoKeyError` exception is raised.

The next step is to initialize some of the encoder state specific attributes by calling the `init_state` method on the encoder module instance which simply stores the currently defined decoder key offset, size, and pack as attributes of the encoder state as conveyed through the accessor methods on the encoder module instance itself. The encoder state then has the string of bad characters and the raw buffer set as attributes so that they can be contextually referenced throughout the encoding process.

With the encoder state finally initialized, the next step is to begin the encoding process by calling the `encode_begin` method on the encoder module instance. This method simply does nothing in its default implementation, but it is designed to allow derived encoder modules to alter the attributes of the encoder state prior to actually starting the encoding process. Once `encode_begin` returns, the `encode` method makes a call into the `do_encode` method by passing it the buffer, bad characters, and initialized encoder state. This is the method that does the actual encoding work and could possibly be overridden if the default implementation was not suitable for a given encoder.

Once `do_encode` completes, the `encode` method makes a call into `encode_end` and passes the encoder state as an argument. The default implementation of this method simply does nothing, but it is provided as a means by which an encoder can hook into the finalization of the encoding process to alter the results that will be returned to the caller.

6.1.2 do_encode

The `do_encode` method is the actual workhorse of the encoding process. It starts by making a copy of the decoder stub by calling the encoder module instance's `decoder_stub` method and passing it the encoder state as an argument. The `decoder_stub` method is the only one that takes an encoder state as an argument as some encoders may generate dynamic decoder stubs depending on the state.

After obtaining the decoder stub, the next step is to substitute the packed version of the decoder key at whatever offset was conveyed in the decoder information hash through the `KeyOffset` and `KeySize` as well as the `KeyPack`. These attributes are gotten through the encoder state's attributes since it's possible that a derived encoder may wish to alter their values to be non-static between iterations of the encoding process.

Finally, the actual block-based encoding occurs by simply walking the raw buffer in block size chunks calling the `encode_block` method on each chunk. This method is passed the encoder state and the chunk to be encoded. By default, the `encode_block` method simply returns the block it is passed, but all encoders are intended to override this method to return the encoded value of the block based on the current encoder state.

After all the blocks have been encoded, the encoder state's `encoded` attribute will contain the encoded version of each blocked. The `do_encode` method then prepends the decoder stub to the front of the encoded buffer and then checks to see if the complete stub + encoded buffer has any bad characters. If bad characters are found, a `Msf::BadcharError` exception is raised to the caller indicating what character and position the bad character was found at in the encoded buffer. If all goes well, the `do_encode` method returns true.

6.1.3 Helper methods

Internal the encoder module class are some instance helper methods that can be used by derived classes to make things easier. For instance, the encoder module base class has a method called `has_badchars?` that can be used to check to see if the supplied buffer has any of the supplied bad characters. If it does, the index of the first bad character found is returned. Otherwise, `nil` is returned.

6.2 Exploit

Exploit modules are used to leverage vulnerabilities in a manner that allows the framework to execute arbitrary code. This broad definition encompasses things like command execution and code execution which are described in terms

of payloads in the framework nomenclature. Support for exploit modules is provided through the `Msf::Exploit` base class. All exploit modules must derive from the `Msf::Exploit` base class at some level. The primary interface exposed by exploit modules to the framework are methods that can be used to check to see if a target is vulnerable and to actually launch the exploit. These methods will be discussed more later in this section.

Like the module information hash, exploit modules have a few exploit module specific information hash elements that are used to control the way the framework interacts with the exploit module and to control the exploit module itself. These exploit module specific hash elements are described in the table shown in figure 6.4.

Hash Element	Accessor	Type	Description
Stance	stance	Exploit::Stance	One of <code>Exploit::Stance::Aggressive</code> or <code>Exploit::Stance::Passive</code> .
Targets	targets	Array	An array of <code>Msf::Target</code> instances.
DefaultTarget	default_target	Fixnum	The default target index to use, if any.
Payload	payload_info	Hash	A hash of elements that controls the exploit's interaction with payloads.

Figure 6.4: `Msf::Exploit` information hash elements

The following subsections will describe the distinctions between different types and stances of exploit modules as well as the interfaces that can be used to operate upon them.

6.2.1 Stances

In the 3.0 version of the framework, exploit modules are designed to take a stance that describes how they go about exploiting their vulnerability at a very general level. While there is much debate in how this breakdown should occur, the framework puts them into two basic categories called *stances*. The first stance that an exploit can take is an aggressive stance. In this mode, an exploit is actively triggering an exploit. The second stance that an exploit can take is a passive stance. In this mode, an exploit is waiting for something to occur, such as a client connecting to a server, so that the exploit can be triggered. Stances are not designed to take locality into account. They merely break down the manner in which the exploit will operate.

The framework uses the exploit's stance to figure out whether how it should

go about executing the `exploit` method. For instance, passive exploits are implied to take longer because they are waiting for some event to trigger the exploitation. For that reason, it is better for the framework to run passive exploits in the context of a job rather than blocking on their exploit routine. Furthermore, passive exploits may be capable of exploiting more than one target before they are completed.

For a module to indicate a passive stance it should initialize the `Stance` information hash element to `Msf::Exploit::Stance::Passive`. If a module wishes to take an aggressive stance, which is the default, it should initialize the `Stance` information hash element to `Msf::Exploit::Stance::Aggressive`.

6.2.2 Types

To further categorize exploits, each exploit is described in terms of an *exploit type*. The purpose of the exploit type is to indicate the locality of the exploit in terms of whether or not it is exploiting a remote machine, a local application, or is capable of operating as both types.

The remote exploit type, as indicated by `Msf::Exploit::Type::Remote`, is used to tell the framework that the exploit is designed to operate against a target other than that of the local machine. While this doesn't explicitly limit the exploit to the use of network communication, that is typically what is implied. Exploit modules can indicate that they are a remote exploit module by inheriting from `Msf::Exploit::Remote` which inherits from `Msf::Exploit`.

The local exploit type, as indicated by `Msf::Exploit::Type::Local`, is used to tell the framework that the exploit is designed to operate against an application or service running on the local machine. This definition typically limits it to exploitation by means other than network communication on the local machine. Exploits modules can indicate that they are a local exploit module by inheriting from `Msf::Exploit::Local` which inherits from `Msf::Exploit`.

The third exploit type, `Msf::Exploit::Type::Omni`, is used to indicate to the framework that the exploit module is capable of operating both locally and remotely. Exploit modules that fit this criteria should inherit from the `Msf::Exploit` class directly.

6.2.3 Interface

To interact with exploit modules, the framework uses a well-defined interface that is exposed by the exploit module base class. These methods, along with their purposes, are described in the following subsections.

check

The exploit module `check` method is used to indicate whether or not a remote machine is thought to be vulnerable. The default implementation of the `check` method simply returns that it is unsupported by the exploit module. However, a complete set of codes can be returned from the `check` method as shown in the table in figure 6.5.

Check Code	Description
Exploit::CheckCode::Safe	The target is not exploitable.
Exploit::CheckCode::Detected	The target service is running, but could not be validated.
Exploit::CheckCode::Appears	The target appears to be vulnerable.
Exploit::CheckCode::Vulnerable	The target is vulnerable.
Exploit::CheckCode::Unsupported	The exploit does not support <code>check</code> .

Figure 6.5: Codes returned from calls to `exploit.check`

exploit

The exploit module's `exploit` method is the entry point that is used to kick off the exploitation process. Prior to calling this method, the framework will have ensured that all required options have been set and that a payload has been generated for use by the exploit. After that, it's up to the exploit to perform whatever action is necessary to trigger the vulnerability in question.

setup

If a payload instance has been created and assigned to the exploit, the `setup` method will initialize the payload's handler by calling `setup_handler` on it and will start the handler by calling `start_handler`. The `setup` method is called by the framework prior to calling the exploit module's `exploit` method.

cleanup

The `cleanup` method gives an exploit module the chance to remove any resources that were created during the call to `exploit` and also gives the exploit module base class a chance to call `cleanup_handler` on the payload instance that's associated with the exploit, if there is one.

generate_payload

This method is used by the framework to generate a payload using either a passed payload instance as the argument or by using the `payload_instance` attribute of the exploit module instance. The return value is an instance of an `EncodedPayload` that takes into account some of the limiting payload factors described in the exploit module's `payload_info` hash. It also takes into account any target-specific limiting payload factors. The resulting encoded payload is assigned to the exploit module's `payload` attribute.

generate_single_payload

This method generates an encoded payload using either the supplied payload instance or the exploit's assigned payload instance and returns it to the caller in the form of an `EncodedPayload` instance. The encoded payload is not assigned as an instance attribute.

regenerate_payload

The `regenerate_payload` method is simply a wrapper around the `generate_single_payload` assuming the exploit's payload instance as the first parameter.

6.2.4 Accessors and Attributes

Exploit modules have a number of accessors and attributes that can be used by derived exploits modules to make their lives easier. These accessors and attributes are described below.

compatible_payloads

This method returns an array of payloads that are compatible with the currently selected target, or with all targets if one has not been selected. The array returned is composed of a two-element array that consists of the name of the reference name of the compatible payload and the class associated with the payload. This method takes into account any architecture and platform restrictions specified by the currently selected target, if any.

handler

The **handler** method is used by exploits to pass information on to the associated payload that may be required or useful in detecting if a session has been created. For instance, all find-style payloads require the original connection that was used to trigger the vulnerability. By calling the **handler** method with the socket that was used, the payload can check and see if a session has been created.

make_nops

In some cases an exploit may need to generate a NOP sled outside of the context of normal encoded payload generation. TO do this, a call can be made to the **make_nops** instance method with the length of the sled that should be generated.

nop_generator

This method returns an instance of the first compatible nop generator.

nop_save_registers

This method returns the selected target's NOP save register information if the **target** attribute is **non-nil** and the **target.save_register** attribute is **non-nil**. Otherwise, the module information hash element's **SaveRegisters** value is returned.

payload

This attribute is an instance of a **Msf::EncodedPayload** after a call has been made to **generate_payload**.

payload_append

This method returns the selected target's payload append information if the **target** attribute is **non-nil** and the **target.payload_append** attribute is **non-nil**. Otherwise, the value of the **Append** hash element in the **payload_info** hash is returned.

payload_badchars

This method returns the value of the `BadChars` hash element in the `payload_info` hash is returned.

payload_info

This method returns the value of the `Payload` module information hash element that is used to convey module-specific payload restrictions.

payload_instance

This attribute is set to the payload instance that was used to generate the encoded payload conveyed in the `payload` attribute.

payload_max_nops

This method returns the selected target's payload maximum NOP sled length if the `target` attribute is `non-nil` and the `target.payload_max_nops` attribute is `non-nil`. Otherwise, the value of the `MaxNops` hash element in the `payload_info` hash is returned.

payload_min_nops

This method returns the selected target's payload minimum NOP sled length if the `target` attribute is `non-nil` and the `target.payload_min_nops` attribute is `non-nil`. Otherwise, the value of the `MinNops` hash element in the `payload_info` hash is returned.

payload_prepend

This method returns the selected target's payload append information if the `target` attribute is `non-nil` and the `target.payload_append` attribute is `non-nil`. Otherwise, the value of the `Append` hash element in the `payload_info` hash is returned.

payload_prepend_encoder

This method returns the selected target's payload prepend encoder information if the `target` attribute is `non-nil` and the `target.payload_prepend_encoder`

attribute is `non-nil`. Otherwise, the value of the `PrependEncoder` hash element in the `payload_info` hash is returned.

payload_space

This method returns the selected target's payload maximum payload space if the `target` attribute is `non-nil` and the `target.payload_space` attribute is `non-nil`. Otherwise, the value of the `Space` hash element in the `payload_info` hash is returned.

stack_adjustment

This method returns the instructions associated with adjusting the stack pointer by a fixed amount in an architecture independent fashion. First, the method looks to see if a target-specific stack adjustment has been specified and if so uses that. Otherwise, the method uses the stack adjustment specified as the value of the `StackAdjustment` hash element in the `payload_info` hash. From there, the method tries to generate the instructions associated with the target or module specific architecture.

target

This attribute returns the `Msf::Target` instance associated with the target index that has been set in the module's datastore through the `TARGET` option value. If the index is invalid or `nil`, `nil` is returned.

This attribute is typically used by exploits to get target-specific addressing information.

6.2.5 Mixins

One of the major design changes in the 3.0 version of the framework was the introduction of exploit mixins. The purpose of exploits mixins are to reduce, and in most cases eliminate, the duplicated code that is often shared between exploit modules that attempt to leverage vulnerabilities found in specific protocol implementations. The mixins also provide a way to share code that is often used independent of protocols, such as the generation of an SEH registration record during the exploitation of an SEH overwrite. By placing this code in mixins, the framework can augment the support at shared levels and introduce things like normalized evasion without having to modify every existing exploit. Encapsulation is very powerful.

These mixins are meant to be `include`'d in exploits that need them. More than one mixin can be included in a single exploit.

As the framework grows, the number of exploit mixins that can be used by modules will grow as well. This document will attempt to show some of the existing mixins.

Msf::Exploit::Brute

The brute force mixin provides a flexible implementation that can be used in a generic fashion for exploits that wish to support brute forcing. This mixin implements the `exploit` method and detects if the currently selected target is a brute force target. If it is, the mixin does all the required address walking based on target specified start addresses and stop addresses. During each iteration, the mixin calls the `brute_exploit` method with the current address state which should be implemented by the derived class. If the `exploit` method is called with a target that is not intended for brute forcing, the mixin calls the `single_exploit` method.

Msf::Exploit::Egghunter

The purpose of the egghunter mixin is to encapsulate the generation of an architecture and platform specific egghunter as provided by the `Rex::Exploitation::Egghunter` class. This feature is provided by the mixin's `generate_egghunter` method which takes into account the currently selected target's platform and architecture.

Msf::Exploit::Remote::DCERPC

The DCERPC mixin provides methods that are useful to exploits that attempt to leverage vulnerabilities in DCERPC applications. It also provides a unified evasion interface that makes it so any exploits that use the mixin can make use of multi-context bind evasion and packet fragmentation.

This mixin automatically registers the `RHOST` and `RPORT` options. It also registers two advanced options, `DCEFragSize` and `DCEMultiBind`.

Msf::Exploit::Remote::Ftp

The FTP mixin provides a set of methods that are useful when interacting with an FTP server, such as logging into the server and sending some of the basic commands. This mixin includes the `Msf::Exploit::Remote::Tcp` mixin.

This mixin automatically registers the `RHOST`, `RPORT`, `USER`, and `PASS` options.

Msf::Exploit::Remote::HttpClient

The HTTP client mixin wraps some of the methods for creating an instance of a `Rex::Proto::Http::Client` such that derived exploits can simply call `connect` on their module instance to establish an HTTP connection to a remote server. This mixin also automatically registers the `RHOST`, `RPORT`, and `VHOST` options.

Msf::Exploit::Remote::HttpServer

The HTTP server mixin wraps the creation or re-use of a local HTTP server that is used in the exploitation of HTTP clients, like web-browsers. This mixin also includes the `Msf::Exploit::Remote::TcpServer` mixin.

Msf::Exploit::Remote::SMB

The SMB mixin implements methods that are useful when exploiting vulnerabilities over the SMB protocol. It provides methods for connecting and logging into an SMB server as well as other helper methods for operating on the SMB connection once established. This mixin includes the `Msf::Exploit::Remote::Tcp` mixin.

This mixin automatically registers the `RPORT`, `SMBDirect`, `SMBUSER`, `SMBPASS`, `SMBDOM`, and `SMBNAME` options. It also registers the `SMBPipeWriteMinSize`, `SMBPipeWriteMaxSize`, `SMBPipeReadMinSize`, and `SMBPipeReadMaxSize` advanced options.

Msf::Exploit::Remote::Tcp

The TCP mixin implements a basic TCP client interface that can be used in a generic fashion to connect or otherwise communicate with applications that speak over TCP.

This mixin automatically registers the `RPORT`, `RHOST`, and `SSL` options.

Msf::Exploit::Remote::TcpServer

The TCP server mixin implements a basic TCP server that can be used to exploit vulnerabilities in clients that speak over TCP.

This mixin automatically registers the `SRVHOST` and `SRVPORT` options.

Msf::Exploit::Remote::Udp

The UDP mixin implements a basic UDP client interface that can be used in a generic fashion to connect or otherwise communicate with applications that speak over UDP.

This mixin automatically registers the `RPORT`, `RHOST`, and `SSL` options.

Msf::Exploit::Seh

The SEH mixin implements some wrapper methods that can be used by exploits that leverage the SEH overwrite exploitation vector. The purpose of this mixin is to wrap the generation of SEH registration records in such a way that it's possible to take into account higher evasion levels. This is accomplished by using the `Rex::Exploitation::Seh` class.

This mixin automatically registers the `DynamicSehRecord` advanced option.

6.3 Nop

NOP generator modules are used to create a string of instructions that have no real affect when executed on a machine other than altering the state of registers or toggling processor flags. All nop modules must inherit from the `Msf::Nop` base class at some level. Nop modules are fairly simplistic when compared to the other types of modules in the framework. There are only two methods that the framework uses when dealing with nop modules.

6.3.1 generate_sled

The `generate_sled` method performs the action that the name implies. It takes the size of the NOP sled to generate as the first argument and a hash of optional parameters as the second argument. The hash controls some of the behaviors of the NOP generator. The table shown in figure 6.6 shows the hash elements that may be passed by the framework to `generate_sled`.

Once sled generation has completed, the return value from `generate_sled` is the the NOP sled buffer if it succeeds.

Hash Element	Type	Description
Random	Bool	Indicates that random NOP generation should be used.
SaveRegisters	Array	An array of architecture-specific registers that should not be touched by instructions generated in the NOP sled.
BadChars	String	The string of bad characters, if any, that should be avoided by the NOP sled.

Figure 6.6: `Msf::Nop` `generate_sled` optional hash arguments

6.3.2 `nop_repeat_threshold`

This method simply returns the default number of times to attempt to find a valid NOP byte when generating the NOP sled. The default is 10000. This is primarily used as a reference for nop modules during sled generation.

6.4 Payload

Payload modules provide the framework with code that can be executed after an exploit succeeds in getting control of execution flow. Payloads can be either command strings or raw instructions, but in the end they boil down into code that will be executed on the target machine. To provide this feature-set, the framework offers the `Msf::Payload` base class that implements routines that are common to all payloads as well as providing some helpful attributes.

One of the major differences between payload modules and other types of modules in the framework is that they are a composition of a few different mixins that lead to a complete payload feature set. Payloads are at their base an implementation of the `Msf::Payload` class. However, they also include the support necessary to handle the client half of any connections that the payload might make through *handlers*. Handlers will be discussed in more detail later in this section. Aside from handlers, payloads are also broken down into three separate payload types: singles, stagers, and stages. These payload types will be discussed in more detail later in this chapter.

Furthermore, unlike other framework modules, payload modules will not necessarily correspond one-to-one with the module names that can be used within the framework. This is because the framework will automatically generate permutations of different module types so that they can be used in various combinations without having to be linked together statically. This is especially useful for staged payloads because it is possible for stagers and stages to be automatically merged together at load time rather than having to statically build an associa-

tion in the module files. This is a major enhancement from the 2.x framework version.

To better help with visualizing the payload hierarchy, the diagram in figure 6.7 shows the class hierarchy of a particular type of payload known as a staged payload.

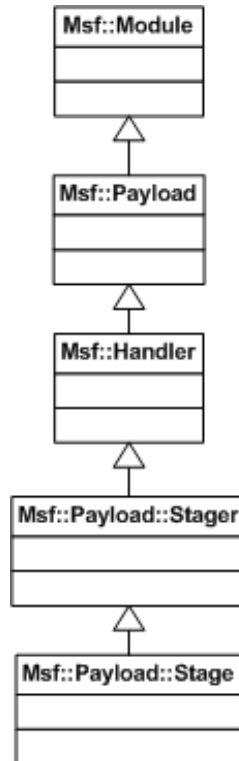


Figure 6.7: Staged payload class hierarchy

6.4.1 Interface

The framework uses a well-defined, uniform interface to work with payload modules. Like other modules, payload modules also have module-specific information hash elements. The table shown in figure 6.8 shows the elements that are specific to payload module information hash and the accessors that can be used to access them.

Using the payload-specific information, the framework drives the payload class by using a specific set of methods. These methods are described in detail below.

Hash Element	Accessor	Type	Description
BadChars	badchars	String	The string of bad characters for this payload, if any.
SaveRegisters	save_registers	Array	An array of architecture specific registers that should be saved when using this payload.
Payload	module_info['Payload']	Hash	A hash of information specific to this payload.
Convention	convention	String	The staging convention used by this payload, if any.
SymbolLookup	symbol_lookup	String	The method used to resolved symbols by this payload, if any.
Handler	handler_class	Msf::Handler::Xxx	The handler class to be used with this payload, or Msf::Handler::None .
Session	session	Msf::Session::Xxx	The session class to create when the payload succeeds.

Figure 6.8: Msf::Payload information hash accessors

compatible_convention?

This method checks to see if the supplied staging convention is compatible with the current payload module's staging convention. If the current payload's staging convention is undefined (as would be the case for a non-staged payload) or the conventions match, then true is returned. Alternatively, if the current payload's type is that of a stager and the supplied convention is undefined, then true is also returned. In every other case, false is returned.

compatible_encoders

This method returns an array of compatible encoders where each element in the array is an array with two elements that contains the reference name of the encoder and the encoder's module class.

compatible_nops

This method returns an array of compatible NOP generators where each element in the array is an array with two elements that contains the reference name of the NOP generator and the nop's module class.

connection_type

This method returns the type of connection being used for this payload as derived from the payload's handler.

generate

This method causes the underlying payload to be generated. This method works by calling the `payload` method on the payload module instance and creating a duplicate copy of it. From there, any defined variables are substituted as conveyed through the `offsets` attribute. The resultant substituted buffer is then returned to the caller.

payload_type

This method returns the type of the payload that is implemented by the derived class. This can be one of `Msf::Payload::Type::Single`, `Msf::Payload::Type::Stager`, or `Msf::Payload::Type::Stage`.

size

This method returns the size of the payload as returned by a call to `generate`.

staged?

This method returns true if the payload type is either `Stager` or `Stage`.

substitute_vars

This method substitutes variables using the `offsets` hash as a guide. It also calls `replace_var` prior to doing substitution which gives derived classes a chance to do custom variable substitution prior to using built-in facilities.

validate

This method wraps the call to the payload's option container's `validate` method.

6.4.2 Types

Framework payloads are broken down into three distinct payload types. The first type of payload that can be implemented is referred to as a *single* payload. Single payloads are self-contained, single stage payloads that do not undergo a staging process. An example of a typical single payload is one that connects back to an attacker and supplies them with a shell without any intermediate staging. The second type of payload is referred to as a *stager*. Stagers are responsible for connecting back to the attacker in some fashion and processing a second stage payload. The third type of payload is referred to as a *stage* and it is what's executed by a stager payload. These three payload types allow the framework to dynamically generate various combinations of payloads.

Single

As described above, single payloads are self-contained, single-stage payloads that perform one logical task without requiring any secondary code. Single payloads are the simplest of the three payload types because they correlate one-to-one with the payloads that end up being generated by the framework.

For single payloads, the module information hash's `Payload` hash element will contain a sub-hash with a few key elements. The table shown in figure 6.9 describes the hash elements that are used by the framework and the accessors that are used to obtain them.

Hash Element	Accessor	Type	Description
Payload	payload	String	The raw payload associated with this payload module.
Offsets	offsets	Hash	An array of variables that should be substituted at specific offsets based on the module's datastore.

Figure 6.9: Payload information sub-hash accessors

For single payloads, the `Payload` hash typically contains a `Payload` sub-hash element that actually contains the raw payload. This is illustrated below:

```
{
  'Payload' =>
    {
      'Payload' => "\xcc\xcc\xcc",
      'Offsets' => ...
    }
}
```

Stage

A stage payload is an implementation of a connection-independent task like spawning a command shell or running an arbitrary command. Stage payloads are combined with various framework stagers to produce a set of connection-oriented multi-stage payloads. This is done automatically by the framework by associating stage payloads with stagers that have a compatible staging convention. The staging convention describes the manner in which connection information is passed from the stager to the stage in terms of what register might hold a file descriptor, for instance. Stages and stagers are also matched up by their symbol lookup convention if necessary so that stages can assume that certain locations in memory will hold routines that may be useful.

Stage payloads convey their raw payload contents in relation to the **Stage** module information hash element. The sub-hash elements are similar to the single-style payloads in that it has both a **Payload** and an **Offsets** element.

Stage payloads are meaningless unless there is a compatible stager.

Stager

A stager payload is an implementation of a payload that establishes some communication channel with the attacker to read in or otherwise obtain a second stage payload to execute. For example, a stager might connection back to the attacker on a defined port and read in code to execute.

Stagers convey their raw payload contents in relation to the **Stager** module information hash element. The sub-hash elements are similar to single-style payloads in that it has both a **Payload** and an **Offsets** element.

Furthermore, staged payloads have some extra accessor methods that single payloads do not. For instance, the stager's payload and offsets can be obtained through the **payload** and **offsets** accessors. The stage's payload and offsets can be obtained through the **stage_payload** and **stage_offsets** accessors.

The code below shows how those hash elements would be set up:

```
{
  'Stager' =>
    {
      'Payload' => "\xcc\xcc\xcc",
      'Offsets' => ...
    },
  'Stage' =>
    {
      'Payload' => "\xcc\xcc\xcc",
```

```
        'Offsets' => ...
    }
}
```

6.4.3 Handlers

Handlers are one of the critical components of a payload. They are responsible for handling the attacker's half of establishing a connection that might be created by the payload being transmitted via an exploit. The different handlers will be discussed in detail later in this subsection.

Handlers themselves act as mixins that get merged into an actual payload module class. The framework interacts with handlers through a well-defined interface. Prior to initiating an exploit, the framework will call into the payload handler's `setup_handler` and `start_handler` methods that will lead to the initialization of the handler in preparation for a payload connection. When a connection arrives, the handler calls the `handle_connection` method on the payload instance. This method is intended to be overridden as necessary by the payload to do custom tasks. For instance, staged payloads will initiate the transfer of the second stage over the established connection and then call the default implementation which leads to the creation of a session for the connection.

When an exploit has finished, the framework will call into the payload handlers `stop_handler` and `cleanup_handler` methods to stop it from listening for future connections.

Bind TCP

The bind TCP handler is provided through `Msf::Handler::BindTcp`. It will attempt to establish a connection to a target machine on a given port (specified in `LPORT`). If a connection is established, a call is made into `handle_connection` passing along the socket associated with the connection.

Find port

The find port handler is provided by the `Msf::Handler::FindPort` class. When an exploit calls the `handler` method with a socket connection, the find port handler will attempt to see if the socket has now been re-purposed for use by the payload. The find port handler is meant to be used for payloads that search for a socket by comparing peer port names relative to the target machine.

Find tag

The find port handler is provided by the `Msf::Handler::FindTag` class. When an exploit calls the `handler` method with a socket connection, the find port handler will attempt to see if the socket has now been re-purposed for use by the payload. The find tag handler is meant to be used for find socket style payloads that search for a socket based on the presence of a tag on the wire.

None

If a payload does not establish a connection of any sort, the `Msf::Handler::None` handler is used.

Reverse TCP

The reverse TCP handler is provided by the `Msf::Handler::ReverseTcp` class. It will listen on a port for incoming connections and will make a call into `handle_connection` with the client sockets as they do.

6.5 Recon

The reconnaissance module is still undergoing design review and will not be documented at this time.

Chapter 7

Framework Plugins

The 3.0 version of the framework offers a new type of framework concept which is that of the *framework plugin*. Unlike modules, framework plugins are designed to alter or augment the framework itself. The scope under which plugins fall is intentionally very broad as to encourage free flowing creativity with what they might be capable of doing. The interface for a plugin is intentionally very simple. All plugins must exist under the `Msf::Plugin` namespace and they must inherit the `Msf::Plugin` base class. Plugins are loaded into the framework by calling `framework.plugins.load` with a file path that contains the plugin. The framework will then take care of loading the plugin and creating an instance of the class found within the file specified, assuming the class was added to the `Msf::Plugin` namespace.

When the framework creates an instance of a plugin, it calls the plugin's constructor and passes it the framework instance that it's being created from. It also passes along a hash of arbitrary parameters, some of which have a well-defined purpose as described in the chapter on the plugin manager in the framework core documentation. Alternatively, a plugin could be passed custom initialization parameters through the options hash.

To understand the types of things a framework plugin is capable of, a few different theoretical examples will be enumerated in this chapter. The first example would be a plugin that simply adds a new command to the console interface when loaded that performs some simple task. The sample plugin included with the default distribution of the framework illustrates how this can be accomplished. A more advanced plugin might automate some of the actions taken when a Meterpreter session is created, such as by automatically downloading the remote machine's password hashes and passing them off to a cracking program.

Another example of a plugin would be introducing an entirely new module type

into the framework. This would be accomplished by extending the existing framework instance to support accessors for dealing with the new module type.

Chapter 8

Framework Sessions

The typical end-game for an exploit is to provide the attacker with some type of session that allows them to run commands or perform other actions on a target machine. In most cases, this session is a typical command interpreter that has had its input and output piped over a socket connection to the attacker. However, a command shell in and of itself is no particularly automatable unless wrapped in a class that allows access to the shell from the level of a command script. It is for this reason that the 3.0 version of the framework emphasizes generalized session classes that can be used by the framework, plugins, and external scripts to automate the process of controlling a session that is created after an exploit succeeds.

To provide an extensible level of automation control, framework sessions can implement one or more of the provider mixins found under the `Msf::Session::Provider` namespace. The current distribution of the framework provides four basic provider interfaces that can be implemented by specific sessions.

1. `MultiCommandExecution`

This interface provides methods that can be used to execute multiple simultaneous commands on the target machine. This interface is a super-set of the `SingleCommandExecution` interface.

2. `MultiCommandShell`

This interface provides methods for executing multiple command shells simultaneously on the target machine. This interface is a super-set of the `SingleCommandShell` interface.

3. `SingleCommandExecution`

This interface provides methods for executing a single command on the target machine.

4. `SingleCommandShell`

This interface provides methods for executing a single command shell on the target machine.

By implementing one or more of these methods, sessions can be made programmatically automatable at the most basic level. Aside from the standard interfaces, sessions can also optionally implement the `Msf::Session::Comm` mixin which is intended to be used for channeling network traffic through a remote machine. Sessions that implement the `Msf::Session::Comm` mixin can be used in conjunction with the switch board routing table present in the Rex library.

At the time of this writing, there are two basic session implementations that are found in the framework base library. These two sessions are described in the following sections.

8.1 Command Shell

The command shell session provided through `Msf::Sessions::CommandShell` implements the `Msf::Session::Provider::SingleCommandShell` interface. The methods used to interact with the shell are simply tunneled over the stream associated with the remote side of the connection. Any payload that renders a command shell should return an instance of this session.

8.2 Meterpreter

The meterpreter session provided through `Msf::Sessions::Meterpreter` implements the `Msf::Session::Comm` interface and is also capable of implementing some of the other automated interfaces. By implementing the `Comm` interface, all meterpreter sessions can be used for pivoting network traffic.

Chapter 9

Methodologies

One of the most critical things to understand prior to attempting to write a module for the framework are some of the methodologies that should be undertaken. The goal of the 3.0 version of the framework is to make modules easier to implement and at the same time make them more robust. With that goal in mind, all programmers wishing to write framework modules should heed the advice from this chapter.

First and foremost, modules should be simple. In the event that a module is becoming complicated or large, it may be best to take a step back and see if any of the code being put into it might be better generalized in a mixin that could later be shared with other modules. This is especially true in the event that an exploit is dealing with a protocol that may later be useful to other exploits. An equally true case is when an exploit is attempting to trigger a vulnerability that has a generalized approach that could be applied to other exploit modules.

Secondly, modules should be clean. One of the key factors when doing any sort of development is to ensure consistency in both design and implementation. This applies not only to naming schemes but also to things like indentation. If a module has inconsistent indentation and/or naming schemes, its readability will be drastically reduced. Every programmer is entitled to their own coding style, but they should be sure to stick with it throughout the development of a given unit.

Finally, encapsulation is king. If a module needs to perform an action that could perhaps be changed to a different algorithm at a later date, encapsulating the operation in a generalized interface is a great way to ensure that code does not have to be rewritten or otherwise altered in the future.

Appendix A

Samples

This chapter contains various samples that illustrate how the framework and other libraries can be interacted with to perform various tasks. The source code to these samples can be found in the documentation directory that is included with all releases of the 3.0 version of the framework.

A.1 Framework

This section contains samples specific to interacting with the framework itself.

A.1.1 Dumping module info

This sample demonstrates how a module's information can be easily serialized to a readable format.

```
#!/usr/bin/ruby

$:.unshift(File.join(File.dirname(__FILE__), '..', '..', '..',
  'lib'))

require 'msf/base'

if (ARGV.empty?)
  puts "Usage: #{File.basename(__FILE__)} module_name"
  exit
end

framework = Msf::Simple::Framework.create

begin
```

```

    # Create the module instance.
    mod = framework.modules.create(ARGV.shift)

    # Dump the module's information in readable text format.
    puts Msf::Serializer::ReadableText.dump_module(mod)
  rescue
    puts "Error: #{$!}\n\n#{@.join("\n")}"
  end
end

```

A.1.2 Encoding the contents of a file

This sample demonstrates how a file can be encoded using a framework encoder.

```

#!/usr/bin/ruby

$.unshift(File.join(File.dirname(__FILE__), '..', '..', '..',
  'lib'))

require 'msf/base'

if (ARGV.empty?)
  puts "Usage: #{File.basename(__FILE__)} encoder_name file_name format"
  exit
end

framework = Msf::Simple::Framework.create

begin
  # Create the encoder instance.
  mod = framework.encoders.create(ARGV.shift)

  puts(Msf::Simple::Buffer.transform(
    mod.encode(IO.readlines(ARGV.shift).join), ARGV.shift || 'ruby'))
rescue
  puts "Error: #{$!}\n\n#{@.join("\n")}"
end

```

A.1.3 Enumerating modules

This sample demonstrates enumerating all of the modules in the framework and displays their module type and reference name.

```

#!/usr/bin/ruby

$.unshift(File.join(File.dirname(__FILE__), '..', '..', '..',
  'lib'))

require 'msf/base'

framework = Msf::Simple::Framework.create

# Enumerate each module in the framework.

```

```

framework.modules.each_module { |name, mod|
  puts "#{mod.type}: #{name}"
}

```

A.1.4 Running an exploit using framework base

This sample demonstrates using the framework core directly to launch an exploit. It makes use of the simplified exploit wrapper method provided by the `Msf::Simple::Exploit` mixin.

```

#!/usr/bin/ruby

$.unshift(File.join(File.dirname(__FILE__), '..', '..', '..',
  'lib'))

require 'msf/base'

if (ARGV.length == 0)
  puts "Usage: #{File.basename(__FILE__)} exploit_name payload_name OPTIONS"
  exit
end

framework = Msf::Simple::Framework.create
exploit_name = ARGV.shift || 'test/multi/aggressive'
payload_name = ARGV.shift || 'windows/meterpreter/reverse_tcp'
input = Rex::Ui::Text::Input::Stdio.new
output = Rex::Ui::Text::Output::Stdio.new

begin
  # Initialize the exploit instance
  exploit = framework.exploits.create(exploit_name)

  # Fire it off.
  session = exploit.exploit_simple(
    'Payload' => payload_name,
    'OptionStr' => ARGV.join(' '),
    'LocalInput' => input,
    'LocalOutput' => output)

  # If a session came back, try to interact with it.
  if (session)
    output.print_status("Session #{session.sid} created, interacting...")
    output.print_line

    session.init_ui(input, output)

    session.interact
  else
    output.print_line("Exploit completed, no session was created.")
  end
end

rescue
  output.print_error("Error: #{!}\n\n#{$.join("\n")}")
end

```

A.1.5 Running an exploit using framework core

This sample demonstrates using the framework core directly to launch an exploit. It uses the framework base Framework class so that the distribution module path is automatically set, but relies strictly on framework core classes for everything else.

```
#!/usr/bin/ruby

$.unshift(File.join(File.dirname(__FILE__), '..', '..', '..',
  'lib'))

require 'msf/base'

if (ARGV.length == 0)
  puts "Usage: #{File.basename(__FILE__)} exploit_name payload_name OPTIONS"
  exit
end

framework = Msf::Simple::Framework.create
exploit_name = ARGV.shift || 'test/multi/aggressive'
payload_name = ARGV.shift || 'windows/meterpreter/reverse_tcp'
input = Rex::Ui::Text::Input::Stdio.new
output = Rex::Ui::Text::Output::Stdio.new

begin
  # Create the exploit driver instance.
  driver = Msf::ExploitDriver.new(framework)

  # Initialize the exploit driver's exploit and payload instance
  driver.exploit = framework.exploits.create(exploit_name)
  driver.payload = framework.payloads.create(payload_name)

  # Import options specified in VAR=VAL format from the supplied command
  # line.
  driver.exploit.datastore.import_options_from_s(ARGV.join(' '))

  # Share the exploit's datastore with the payload.
  driver.payload.share_datastore(driver.exploit.datastore)

  # Initialize the target index to what's in the exploit's data store or
  # zero by default.
  driver.target_idx = (driver.exploit.datastore['TARGET'] || 0).to_i

  # Initialize the exploit and payload user interfaces.
  driver.exploit.init_ui(input, output)
  driver.payload.init_ui(input, output)

  # Fire it off.
  session = driver.run

  # If a session came back, try to interact with it.
  if (session)
    output.print_status("Session #{session.sid} created, interacting...")
    output.print_line

    session.init_ui(input, output)
  end
end
```

```

        session.interact
    else
        output.print_line("Exploit completed, no session was created.")
    end

rescue
    output.print_error("Error: #{$!}\n\n#{$.join("\n")}")
end

```

A.2 Framework Module

This section shows some sample framework modules.

A.2.1 Encoder

This sample illustrates a very basic encoder that simply returns the block that it's passed.

```

module Msf
  module Encoders

    class Sample < Msf::Encoder

      def initialize
        super(
          'Name'           => 'Sample encoder',
          'Version'        => '$Revision: 1.30 $',
          'Description'    => %q{
            Sample encoder that just returns the block it's passed
            when encoding occurs.
          },
          'Author'         => 'skape',
          'Arch'           => ARCH_ALL)
      end

      #
      # Returns the unmodified buffer to the caller.
      #
      def encode_block(state, buf)
        buf
      end

    end

  end

end

```

A.2.2 Exploit

This exploit sample shows how an exploit module could be written to exploit a bug in an arbitrary TCP server.

```

module Msf

class Exploits::Sample < Msf::Exploit::Remote

  #
  # This exploit affects TCP servers, so we use the TCP client mixin.
  #
  include Exploit::Remote::Tcp

  def initialize(info = {})
    super(update_info(info,
      'Name'          => 'Sample exploit',
      'Description'   => %q{
        This exploit module illustrates how a vulnerability could be exploited
        in an TCP server that has a parsing bug.
      },
      'Author'        => 'skape',
      'Version'       => '$Revision: 1.30 $',
      'Payload'       =>
        {
          'Space'     => 1000,
          'BadChars' => "\x00",
        },
      'Targets'       =>
        [
          # Target 0: Windows All
          [
            'Windows Universal',
            {
              'Platform' => 'win',
              'Ret'      => 0x41424344
            }
          ],
        ],
      'DefaultTarget' => 0))
  end

  #
  # The sample exploit just indicates that the remote host is always
  # vulnerable.
  #
  def check
    return Exploit::CheckCode::Vulnerable
  end

  #
  # The exploit method connects to the remote service and sends 1024 A's
  # followed by the fake return address and then the payload.
  #
  def exploit
    connect

    print_status("Sending #{payload.encoded.length} byte payload...")

    # Build the buffer for transmission
    buf = "A" * 1024
    buf += [ target.ret ].pack('V')
  end
end

```



```

        buf += payload.encoded

        # Send it off
        sock.put(buf)
        sock.get

        handler
    end
end
end

```

A.2.3 Nop

This class implements a very basic NOP sled generator that just returns a string of 0x90's for the supplied sled length.

```

module Msf
  module Nops

    class Sample < Msf::Nop

      def initialize
        super(
          'Name'          => 'Sample NOP generator',
          'Version'       => '$Revision: 1.30 $',
          'Description'   => 'Sample single-byte NOP generator',
          'Author'        => 'skape',
          'Arch'          => ARCH_X86)
      end

      #
      # Returns a string of 0x90's for the supplied length.
      #
      def generate_sled(length, opts)
        "\x90" * length
      end
    end
  end
end
end

```

A.2.4 Payload

This sample payload is designed to trigger a debugger exception via int3.

```

module Msf
  module Payloads
    module Singles

```

```

module Sample

  include Msf::Payload::Single

  def initialize(info = {})
    super(update_info(info,
      'Name' => 'Debugger Trap',
      'Version' => '$Revision: 1.30 $',
      'Description' => 'Causes a debugger trap exception through int3',
      'Author' => 'skape',
      'Platform' => 'win',
      'Arch' => ARCH_X86,
      'Payload' =>
        {
          'Payload' => "\xcc"
        }
    ))
  end

end

end

end

end

```

A.2.5 Recon

Reconnaissance modules are undergoing design review and do not have any samples available at this time.

A.3 Framework Plugin

A.3.1 Console user interface plugin

This class illustrates a sample plugin. Plugins can change the behavior of the framework by adding new features, new user interface commands, or through any other arbitrary means. They are designed to have a very loose definition in order to make them as useful as possible.

```

module Msf

  class Plugin::Sample < Msf::Plugin

    ###
    #
    # This class implements a sample console command dispatcher.
    #
    ###
    class ConsoleCommandDispatcher
      include Msf::Ui::Console::CommandDispatcher

      #
    end
  end
end

```

```

# The dispatcher's name.
#
def name
  "Sample"
end

#
# Returns the hash of commands supported by this dispatcher.
#
def commands
  {
    "sample" => "A sample command added by the sample plugin"
  }
end

#
# This method handles the sample command.
#
def cmd_sample(*args)
  print_line("You passed: #{args.join(' ')}")
end
end

#
# The constructor is called when an instance of the plugin is created. The
# framework instance that the plugin is being associated with is passed in
# the framework parameter. Plugins should call the parent constructor when
# inheriting from Msf::Plugin to ensure that the framework attribute on
# their instance gets set.
#
def initialize(framework, opts)
  super

  # If this plugin is being loaded in the context of a console application
  # that uses the framework's console user interface driver, register
  # console dispatcher commands.
  add_console_dispatcher(ConsoleCommandDispatcher)

  print_status("Sample plugin loaded.")
end

#
# The cleanup routine for plugins gives them a chance to undo any actions
# they may have done to the framework. For instance, if a console
# dispatcher was added, then it should be removed in the cleanup routine.
#
def cleanup
  # If we had previously registered a console dispatcher with the console,
  # deregister it now.
  remove_console_dispatcher('Sample')
end

#
# This method returns a short, friendly name for the plugin.
#
def name
  "sample"
end

```

```
end

#
# This method returns a brief description of the plugin. It should be no
# more than 60 characters, but there are no hard limits.
#
def desc
  "Demonstrates using framework plugins"
end

end
end
```