# Architecture

The solution is separated into a seven projects:

* Sekhmet  
  General purpose support library not written for this project. Used both at runtime and in the tool-chain used during compilation.
* GPPGSupport library for the generated parser – written by the developers of the Garden Point Parser Generator. Used at runtime.
* FamPoly.UtilsTool created as part of a different project[[1]](#footnote-2). The purpose of the tool is to make a few changes to the code generated by the parser and lexer generator tools to make them fit nicer with the rest of the codebase.
* VMILLibA standalone library dealing with the source language. Originally it read and wrote both a textual and binary representation of said language, but as the project progressed the binary format was abandoned.
* VM  
  The main virtual machine binary. This is built as a library that can be included in other applications.
* VM.DebuggingLibrary implementing most of the interface for a debugger. The debug interpreter and execution stack is part of the main VM library but the Windows Communication Foundation interfaces and classes are implemented here. This library is not completed but part of it is used in the Swapper test mode.
* VMShellThe current console based driver for our VM. Simple console based program that simply invokes the virtual machine based on the parameters given.

The static class VirtualMachine (VirtualMachine.cs) implements the interface programs wishing to use the VM. This interface is simply the ability to execute a given file in a synchronous and asynchronous manner (no callback is currently specified for the asynchronous case) as well as the ability to attach and detach a debugger. When requesting the execution of a file the VM is automatically initialized, resulting in the creation of a memory manager and the loading our base library, before execution is begun. Our base library is embedded in the binary but is written in the VM’s source language with references to external methods[[2]](#footnote-3).

Execution itself is performed by creating a new instance of InterpreterThread (InterpreterThread.cs) specifying an object instance and a message handler within defined by the class of that object. Each InterpreterThread instance represents a distinct thread and so creation of a new thread is done in the same manner though initiated from within the VM.

The InterpreterThread then creates a new interpreter using the currently specified IInterpreterFactory (IInterpreter.cs). This factory specifies methods for creating new IInterpreter (IInterpreter.cs) and IExecutionStack (IExecutionStck.cs) instances. The interpreter itself has a single entry point: *Run*. To ensure that the interpreter can be swapped at more or less any point we have an invariant specifying that only the InterpreterThread instance of a given interpreter is allowed to call this entry point. So to ensure that external method calls can call back into the VM a stack of messages stored in the thread is employed. All code has access to the InterpreterThread instance it is executing in and can add a new message to its stack – implemented as .NET delegates – allowing it to call either other external method for the interpreter.

A property in the interpreter ensures that it can be made to return when the currently executing instruction is executing. Note that due to the message stack any external call that the interpreter may initiate is actually relegated to be performed by the InterpreterThread. An interpreter running our own language can thus be paused almost instantly and any running .NET code will pause when returning from the most recently made call – if a thread is blocked it is simply specified that it should pause. Obviously this means that any path that can lead to blocking should be guarded on reactivation to avoid memory accesses when that happens.

To make access to heap objects easy from within the VM each type of heap object recognized by the VM has a corresponding .NET struct. Because this is a managed platform we cannot manipulate memory the way one would in C++ so these structs have a single field representing their address in the heap. Access to the contents of these types is done through static methods. In reality access is gained through a generic handle parameterized with the intended type. To access the name of a class one would call the method Name with an instance of Handle<Class>. Through the magic of extension method in C# 3.0 this call can be made to look like a call to a normal instance method and the compiler simply rewrites it making the code look a lot nicer. The handle class allows us to have GC safe pointers by registering them centrally and updating them when moving objects[[3]](#footnote-4).

As mentioned not all API function can be written in the VM language so external calls are necessary. Currently these are implemented in the classes nested beneath SystemCalls (SystemCalls.cs and SystemCalls.\*.cs). When a reference is made to an external method named System.Reflection.Class.Name the VM expects to find a class .NET SystemCalls.System.Reflection.Class and in that class a method called Name with a signature matching the delegate SystemCall defined in SystemCalls.cs. Each class containing external methods are decorated with the SystemCallClassAttribute (SystemCalls.cs) attribute and likewise each method implementing an external call is decorated with the SystemCallMethodAttribute (SystemCalls.cs). This allows the resolution mechanism implemented in SystemCalls to find, and cache, external methods when they are first accessed.

Memory management is handled by the MemoryManager (MemoryManager.cs) class which acts as the manager of memory managers. This class can hold a number of child memory managers which each operates on a subset of a shared array representing the heap. Currently we only have two different memory managers: a mark-sweep collecting one and a non-collecting one. The idea was to let MemoryManager manage the various generations, but we never got that far.

1. Part of Kim Birkelund’s PhD project. [↑](#footnote-ref-2)
2. The syntax for these external references is part of the language and can be used by anyone. [↑](#footnote-ref-3)
3. Currently we don’t actually move any objects during GC, but the plumbing is in place to support it. [↑](#footnote-ref-4)