SCons User Guide 1.1.0

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Thank you for taking the time to read about SCons. SCons is a next-generation software construction tool, or make tool—that is, a software utility for building software (or other files) and keeping built software up-to-date whenever the underlying input files change.

The most distinctive thing about SCons is that its configuration files are actually scripts, written in the Python programming language. This is in contrast to most alternative build tools, which typically invent a new language to configure the build. SCons still has a learning curve, of course, because you have to know what functions to call to set up your build properly, but the underlying syntax used should be familiar to anyone who has ever looked at a Python script.

Paradoxically, using Python as the configuration file format makes SCons easier for non-programmers to learn than the cryptic languages of other build tools, which are usually invented by programmers for other programmers. This is in no small part due to the consistency and readability that are built in to Python. It just so happens that making a real, live scripting language the basis for the configuration files makes it a snap for more accomplished programmers to do more complicated things with builds, as necessary.

1. SCons Principles

There are a few overriding principles we try to live up to in designing and implementing SCons:

Correctness
First and foremost, by default, SCons guarantees a correct build even if it means sacrificing performance a little. We strive to guarantee the build is correct regardless of how the software being built is structured, how it may have been written, or how unusual the tools are that build it.

Performance
Given that the build is correct, we try to make SCons build software as quickly as possible. In particular, wherever we may have needed to slow down the default SCons behavior to guarantee a correct build, we also try to make it easy to speed up SCons through optimization options that let you trade off guaranteed correctness in all end cases for a speedier build in the usual cases.

Convenience
SCons tries to do as much for you out of the box as reasonable, including detecting the right tools on your system and using them correctly to build the software.

In a nutshell, we try hard to make SCons just "do the right thing" and build software correctly, with a minimum of hassles.
2. A Caveat About This Guide’s Completeness

One word of warning as you read through this Guide: Like too much Open Source software out there, the SCons documentation isn’t always kept up-to-date with the available features. In other words, there’s a lot that SCons can do that isn’t yet covered in this User’s Guide. (Come to think of it, that also describes a lot of proprietary software, doesn’t it?)

Although this User’s Guide isn’t as complete as we’d like it to be, our development process does emphasize making sure that the SCons man page is kept up-to-date with new features. So if you’re trying to figure out how to do something that SCons supports but can’t find enough (or any) information here, it would be worth your while to look at the man page to see if the information is covered there. And if you do, maybe you’d even consider contributing a section to the User’s Guide so the next person looking for that information won’t have to go through the same thing...?

3. Acknowledgements

SCons would not exist without a lot of help from a lot of people, many of whom may not even be aware that they helped or served as inspiration. So in no particular order, and at the risk of leaving out someone:

First and foremost, SCons owes a tremendous debt to Bob Sidebotham, the original author of the classic Perl-based Cons tool which Bob first released to the world back around 1996. Bob’s work on Cons classic provided the underlying architecture and model of specifying a build configuration using a real scripting language. My real-world experience working on Cons informed many of the design decisions in SCons, including the improved parallel build support, making Builder objects easily definable by users, and separating the build engine from the wrapping interface.

Greg Wilson was instrumental in getting SCons started as a real project when he initiated the Software Carpentry design competition in February 2000. Without that nudge, marrying the advantages of the Cons classic architecture with the readability of Python might have just stayed no more than a nice idea.

The entire SCons team have been absolutely wonderful to work with, and SCons would be nowhere near as useful a tool without the energy, enthusiasm and time people have contributed over the past few years. The “core team” of Chad Austin, Anthony Roach, Bill Deegan, Charles Crain, Steve Leblanc, Greg Noel, Gary Oberbrunner, Greg Spencer and Christoph Wiedemann have been great about reviewing my (and other) changes and catching problems before they get in the code base. Of particular technical note: Anthony’s outstanding and innovative work on the tasking engine has given SCons a vastly superior parallel build model; Charles has been the master of the crucial Node infrastructure; Christoph’s work on the Configure infrastructure has added crucial Autoconf-like functionality; and Greg has provided excellent support for Microsoft Visual Studio.

Special thanks to David Snopek for contributing his underlying "Autoscons" code that formed the basis of Christoph’s work with the Configure functionality. David was extremely generous in making this code
available to SCons, given that he initially released it under the GPL and SCons is released under a
less-restrictive MIT-style license.

Thanks to Peter Miller for his splendid change management system, Aegis, which has provided the
SCons project with a robust development methodology from day one, and which showed me how you
could integrate incremental regression tests into a practical development cycle (years before eXtreme
Programming arrived on the scene).

And last, thanks to Guido van Rossum for his elegant scripting language, which is the basis not only for
the SCons implementation, but for the interface itself.

4. Contact

The best way to contact people involved with SCons, including the author, is through the SCons mailing
lists.

If you want to ask general questions about how to use SCons send email to users@scons.tigris.org.

If you want to contact the SCons development community directly, send email to
dev@scons.tigris.org.

If you want to receive announcements about SCons, join the low-volume
announce@scons.tigris.org mailing list.
Chapter 1. Building and Installing SCons

This chapter will take you through the basic steps of installing SCons on your system, and building SCons if you don’t have a pre-built package available (or simply prefer the flexibility of building it yourself). Before that, however, this chapter will also describe the basic steps involved in installing Python on your system, in case that is necessary. Fortunately, both SCons and Python are very easy to install on almost any system, and Python already comes installed on many systems.

1.1. Installing Python

Because SCons is written in Python, you must obviously have Python installed on your system to use SCons. Before you try to install Python, you should check to see if Python is already available on your system by typing `python -V` (capital ‘V’) or `python --version` at your system’s command-line prompt.

```
$ python -V
Python 2.5.1
```

And on a Windows system with Python installed:

```
C:\>python -V
Python 2.5.1
```

If Python is not installed on your system, you will see an error message stating something like "command not found" (on UNIX or Linux) or "'python' is not recognized as an internal or external command, operable program or batch file" (on Windows). In that case, you need to install Python before you can install SCons.

(Note that the -V option was added to Python version 2.0, so if your system only has an earlier version available you may see an "Unknown option: -V" error message.)

The standard location for information about downloading and installing Python is http://www.python.org/download/. See that page for information about how to download and install Python on your system.

SCons will work with any version of Python from 1.5.2 or later. If you need to install Python and have a choice, we recommend using the most recent Python 2.5 version available. Python 2.5 has significant improvements the help speed up the performance of SCons’.
1.2. Installing SCons From Pre-Built Packages

SCons comes pre-packaged for installation on a number of systems, including Linux and Windows systems. You do not need to read this entire section, you should only need to read the section appropriate to the type of system you’re running on.

1.2.1. Installing SCons on Red Hat (and Other RPM-based) Linux Systems

SCons comes in RPM (Red Hat Package Manager) format, pre-built and ready to install on Red Hat Linux, Fedora Core, or any other Linux distribution that uses RPM. Your distribution may already have an SCons RPM built specifically for it; many do, including SuSe, Mandrake and Fedora. You can check for the availability of an SCons RPM on your distribution’s download servers, or by consulting an RPM search site like http://www.rpmfind.net/ or http://rpm.pbone.net/.

If your Linux distribution does not already have a specific SCons RPM file, you can download and install from the generic RPM provided by the SCons project. This will install the SCons script(s) in /usr/bin, and the SCons library modules in /usr/lib/scons.

To install from the command line, simply download the appropriate .rpm file, and then run:

```
# rpm -Uvh scons-0.96-1.noarch.rpm
```

Or, you can use a graphical RPM package manager like gnorpm. See your package manager application’s documentation for specific instructions about how to use it to install a downloaded RPM.

1.2.2. Installing SCons on Debian Linux Systems

Debian Linux systems use a different package management format that also makes it very easy to install SCons.

If your system is connected to the Internet, you can install the latest official Debian package by running:

```
# apt-get install scons
```
Chapter 1. Building and Installing SCons

1.2.3. Installing SCons on Windows Systems

SCons provides a Windows installer that makes installation extremely easy. Download the scons-0.95.win32.exe file from the SCons download page at http://www.scons.org/download.html. Then all you need to do is execute the file (usually by clicking on its icon in Windows Explorer). These will take you through a small sequence of windows that will install SCons on your system.

1.3. Building and Installing SCons on Any System

If a pre-built SCons package is not available for your system, then you can still easily build and install SCons using the native Python distutils package.

The first step is to download either the scons-1.1.0.tar.gz or scons-1.1.0.zip, which are available from the SCons download page at http://www.scons.org/download.html.

Unpack the archive you downloaded, using a utility like tar on Linux or UNIX, or WinZip on Windows. This will create a directory called scons-1.1.0, usually in your local directory. Then change your working directory to that directory and install SCons by executing the following commands:

```
# cd scons-1.1.0
# python setup.py install
```

This will build SCons, install the scons script in the default system scripts directory (/usr/local/bin or C:\Python25\Scripts), and will install the SCons build engine in an appropriate stand-alone library directory (/usr/local/lib/scons or C:\Python25\scons). Because these are system directories, you may need root (on Linux or UNIX) or Administrator (on Windows) privileges to install SCons like this.

1.3.1. Building and Installing Multiple Versions of SCons Side-by-Side

The SCons setup.py script has some extensions that support easy installation of multiple versions of SCons in side-by-side locations. This makes it easier to download and experiment with different versions of SCons before moving your official build process to a new version, for example.

To install SCons in a version-specific location, add the --version-lib option when you call setup.py:

```
# python setup.py install --version-lib
```
Chapter 1. Building and Installing SCons

This will install the SCons build engine in the /usr/lib/scons-1.1.0 or
C:\Python25\scons-1.1.0 directory, for example.

If you use the --version-lib option the first time you install SCons, you do not need to specify it each
time you install a new version. The SCons setup.py script will detect the version-specific directory
name(s) and assume you want to install all versions in version-specific directories. You can override that
assumption in the future by explicitly specifying the --standalone-lib option.

1.3.2. Installing SCons in Other Locations

You can install SCons in locations other than the default by specifying the --prefix= option:

$ python setup.py install --prefix=/opt/scons

This would install the scons script in /opt/scons/bin and the build engine in
/opt/scons/lib/scons.

Note that you can specify both the --prefix= and the --version-lib options at the same type, in
which case setup.py will install the build engine in a version-specific directory relative to the specified
prefix. Adding --version-lib to the above example would install the build engine in
/opt/scons/lib/scons-1.1.0.

1.3.3. Building and Installing SCons Without Administrative
Privileges

If you don’t have the right privileges to install SCons in a system location, simply use the --prefix=
option to install it in a location of your choosing. For example, to install SCons in appropriate locations
relative to the user’s $HOME directory, the scons script in $HOME/bin and the build engine in
$HOME/lib/scons, simply type:

$ python setup.py install --prefix=$HOME

You may, of course, specify any other location you prefer, and may use the --version-lib option if
you would like to install version-specific directories relative to the specified prefix.
Chapter 2. Simple Builds

In this chapter, you will see several examples of very simple build configurations using SCons, which will demonstrate how easy it is to use SCons to build programs from several different programming languages on different types of systems.

2.1. Building Simple C / C++ Programs

Here’s the famous "Hello, World!" program in C:

```c
int main()
{
    printf("Hello, world!\n");
}
```

And here’s how to build it using SCons. Enter the following into a file named `SConstruct`:

```python
Program('hello.c')
```

This minimal configuration file gives SCons two pieces of information: what you want to build (an executable program), and the input file from which you want it built (the `hello.c` file). `Program` is a `builder_method`, a Python call that tells SCons that you want to build an executable program.

That’s it. Now run the `scons` command to build the program. On a POSIX-compliant system like Linux or UNIX, you’ll see something like:

```
% scons
scons: Reading SConscript files ...
scons: done reading SConscript files.
scons: Building targets ...
cc -o hello.o -c hello.c
cc -o hello hello.o
scons: done building targets.
```

On a Windows system with the Microsoft Visual C++ compiler, you’ll see something like:

```
C:\>scons
scons: Reading SConscript files ...
scons: done reading SConscript files.
scons: Building targets ...
cl /Fohello.obj /c hello.c /nologo
```
Chapter 2. Simple Builds

```
link /nologo /OUT:hello.exe hello.obj
scons: done building targets.
```

First, notice that you only need to specify the name of the source file, and that SCons correctly deduces the names of the object and executable files to be built from the base of the source file name.

Second, notice that the same input SConstruct file, without any changes, generates the correct output file names on both systems: `hello.o` and `hello` on POSIX systems, `hello.obj` and `hello.exe` on Windows systems. This is a simple example of how SCons makes it extremely easy to write portable software builds.

(Note that we won’t provide duplicate side-by-side POSIX and Windows output for all of the examples in this guide; just keep in mind that, unless otherwise specified, any of the examples should work equally well on both types of systems.)

### 2.2. Building Object Files

The Program builder method is only one of many builder methods that SCons provides to build different types of files. Another is the Object builder method, which tells SCons to build an object file from the specified source file:

```
Object('hello.c')
```

Now when you run the scons command to build the program, it will build just the `hello.o` object file on a POSIX system:

```
% scons
scons: Reading SConscript files ...
scons: done reading SConscript files.
scons: Building targets ...
cc -o hello.o -c hello.c
scons: done building targets.
```

And just the `hello.obj` object file on a Windows system (with the Microsoft Visual C++ compiler):

```
C:\>scons
scons: Reading SConscript files ...
scons: done reading SConscript files.
scons: Building targets ...
c1 /Fo hello.obj /c hello.c /nologo
scons: done building targets.
```
2.3. Simple Java Builds

SCons also makes building with Java extremely easy. Unlike the Program and Object builder methods, however, the Java builder method requires that you specify the name of a destination directory in which you want the class files placed, followed by the source directory in which the .java files live:

```python
Java('classes', 'src')
```

If the src directory contains a single hello.java file, then the output from running the scons command would look something like this (on a POSIX system):

```
% scons
scons: Reading SConscript files ...
scons: done reading SConscript files.
scons: Building targets ...
javac -d classes -sourcepath src src/hello.java
scons: done building targets.
```

We’ll cover Java builds in more detail, including building Java archive (.jar) and other types of file, in Chapter 27.

2.4. Cleaning Up After a Build

When using SCons, it is unnecessary to add special commands or target names to clean up after a build. Instead, you simply use the -c or --clean option when you invoke SCons, and SCons removes the appropriate built files. So if we build our example above and then invoke `scons -c` afterwards, the output on POSIX looks like:

```
% scons
scons: Reading SConscript files ...
scons: done reading SConscript files.
scons: Building targets ...
cc -o hello.o -c hello.c
c -o hello hello.o
scons: done building targets.
% scons -c
scons: Reading SConscript files ...
scons: done reading SConscript files.
scons: Cleaning targets ...
Removed hello.o
Removed hello
scons: done cleaning targets.
```
Chapter 2. Simple Builds

And the output on Windows looks like:

```
C:\>scons
scons: Reading SConscript files ...
scons: done reading SConscript files.
scons: Building targets ...
cl /Fohello.obj /c hello.c /nologo
link /nologo /OUT:hello.exe hello.obj
scons: done building targets.
C:\>scons -c
scons: Reading SConscript files ...
scons: done reading SConscript files.
scons: Cleaning targets ...
Removed hello.obj
Removed hello.exe
scons: done cleaning targets.
```

Notice that SCons changes its output to tell you that it is `Cleaning targets ... and done cleaning targets`.

2.5. The SConstruct File

If you’re used to build systems like Make you’ve already figured out that the SConstruct file is the SCons equivalent of a Makefile. That is, the SConstruct file is the input file that SCons reads to control the build.

2.5.1. SConstruct Files Are Python Scripts

There is, however, an important difference between an SConstruct file and a Makefile: the SConstruct file is actually a Python script. If you’re not already familiar with Python, don’t worry. This User’s Guide will introduce you step-by-step to the relatively small amount of Python you’ll need to know to be able to use SCons effectively. And Python is very easy to learn.

One aspect of using Python as the scripting language is that you can put comments in your SConstruct file using Python’s commenting convention; that is, everything between a `#` and the end of the line will be ignored:

```
# Arrange to build the "hello" program.
Program('hello.c')  # "hello.c" is the source file.
```

You’ll see throughout the remainder of this Guide that being able to use the power of a real scripting language can greatly simplify the solutions to complex requirements of real-world builds.
2.5.2. SCons Functions Are Order-Independent

One important way in which the SConstruct file is not exactly like a normal Python script, and is more like a Makefile, is that the order in which the SCons functions are called in the SConstruct file does not affect the order in which SCons actually builds the programs and object files you want it to build. In other words, when you call the Program builder (or any other builder method), you’re not telling SCons to build the program at the instant the builder method is called. Instead, you’re telling SCons to build the program that you want, for example, a program built from a file named hello.c, and it’s up to SCons to build that program (and any other files) whenever it’s necessary. (We’ll learn more about how SCons decides when building or rebuilding a file is necessary in Chapter 6, below.)

SCons reflects this distinction between calling a builder method like Program and actually building the program by printing the status messages that indicate when it’s "just reading" the SConstruct file, and when it’s actually building the target files. This is to make it clear when SCons is executing the Python statements that make up the SConstruct file, and when SCons is actually executing the commands or other actions to build the necessary files.

Let’s clarify this with an example. Python has a print statement that prints a string of characters to the screen. If we put print statements around our calls to the Program builder method:

```python
print "Calling Program('hello.c')"
Program('hello.c')
print "Calling Program('goodbye.c')"
Program('goodbye.c')
print "Finished calling Program()"
```

Then when we execute SCons, we see the output from the print statements in between the messages about reading the SConscript files, indicating that that is when the Python statements are being executed:

```
% scons
scons: Reading SConscript files ...
Calling Program('hello.c')
Calling Program('goodbye.c')
Finished calling Program()
scons: done reading SConscript files.
scons: Building targets ...
  cc -o goodbye.o -c goodbye.c
  cc -o goodbye goodbye.o
  cc -o hello.o -c hello.c
  cc -o hello hello.o
scons: done building targets.
```

Notice also that SCons built the goodbye program first, even though the "reading SConscript" output shows that we called Program('hello.c') first in the SConstruct file.
2.6. Making the SCons Output Less Verbose

You’ve already seen how SCons prints some messages about what it’s doing, surrounding the actual commands used to build the software:

```
C:\>scons
scons: Reading SConscript files ...
scons: done reading SConscript files.
scons: Building targets ...
c1 /Fohello.obj /c hello.c /nologo
link /nologo /OUT:hello.exe hello.obj
scons: done building targets.
```

These messages emphasize the order in which SCons does its work: all of the configuration files (generically referred to as SConscript files) are read and executed first, and only then are the target files built. Among other benefits, these messages help to distinguish between errors that occur while the configuration files are read, and errors that occur while targets are being built.

One drawback, of course, is that these messages clutter the output. Fortunately, they’re easily disabled by using the -Q option when invoking SCons:

```
C:\>scons -Q
c1 /Fohello.obj /c hello.c /nologo
link /nologo /OUT:hello.exe hello.obj
```

Because we want this User’s Guide to focus on what SCons is actually doing, we’re going to use the -Q option to remove these messages from the output of all the remaining examples in this Guide.

Notes

1. In programming parlance, the SConstruct file is *declarative*, meaning you tell SCons what you want done and let it figure out the order in which to do it, rather than strictly *imperative*, where you specify explicitly the order in which to do things.
Chapter 3. Less Simple Things to Do With Builds

In this chapter, you will see several examples of very simple build configurations using SCons, which will demonstrate how easy it is to use SCons to build programs from several different programming languages on different types of systems.

3.1. Specifying the Name of the Target (Output) File

You’ve seen that when you call the Program builder method, it builds the resulting program with the same base name as the source file. That is, the following call to build an executable program from the hello.c source file will build an executable program named hello on POSIX systems, and an executable program named hello.exe on Windows systems:

```
Program('hello.c')
```

If you want to build a program with a different name than the base of the source file name, you simply put the target file name to the left of the source file name:

```
Program('new_hello', 'hello.c')
```

(SCons requires the target file name first, followed by the source file name, so that the order mimics that of an assignment statement in most programming languages, including Python: "program = source files".)

Now SCons will build an executable program named new_hello when run on a POSIX system:

```
% scons -Q
cc -o hello.o -c hello.c
cc -o new_hello hello.o
```

And SCons will build an executable program named new_hello.exe when run on a Windows system:

```
C:\>scons -Q
cl /Fohello.obj /c hello.c /nologo
link /nologo /OUT:new_hello.exe hello.obj
```
3.2. Compiling Multiple Source Files

You’ve just seen how to configure SCons to compile a program from a single source file. It’s more common, of course, that you’ll need to build a program from many input source files, not just one. To do this, you need to put the source files in a Python list (enclosed in square brackets), like so:

```python
Program(['prog.c', 'file1.c', 'file2.c'])
```

A build of the above example would look like:

```bash
% scons -Q
cc -o file1.o -c file1.c
cc -o file2.o -c file2.c
cc -o prog.o -c prog.c
cc -o prog prog.o file1.o file2.o
```

Notice that SCons deduces the output program name from the first source file specified in the list--that is, because the first source file was `prog.c`, SCons will name the resulting program `prog` (or `prog.exe` on a Windows system). If you want to specify a different program name, then (as we’ve seen in the previous section) you slide the list of source files over to the right to make room for the output program file name. (SCons puts the output file name to the left of the source file names so that the order mimics that of an assignment statement: "program = source files"). This makes our example:

```python
Program('program', ['prog.c', 'file1.c', 'file2.c'])
```

On Linux, a build of this example would look like:

```bash
% scons -Q
cc -o file1.o -c file1.c
cc -o file2.o -c file2.c
cc -o prog.o -c prog.c
cc -o program prog.o file1.o file2.o
```

Or on Windows:

```bash
C:\>scons -Q
cl /Fofile1.obj /c file1.c /nologo
cl /Fofile2.obj /c file2.c /nologo
cl /Foprog.obj /c prog.c /nologo
link /nologo /OUT:program.exe prog.obj file1.obj file2.obj
```
3.3. Making a list of files with Glob

You can also use the Glob function to find all files matching a certain template, using the standard shell pattern matching characters * , ? and [abc] to match any of a, b or c. [!abc] is also supported, to match any character except a, b or c. This makes many multi-source-file builds quite easy:

```python
Program('program', Glob('*.c'))
```

The SCons man page has more details on using Glob with Variant directories and Repositories, and returning strings rather than Nodes.

3.4. Specifying Single Files Vs. Lists of Files

We’ve now shown you two ways to specify the source for a program, one with a list of files:

```python
Program('hello', ['file1.c', 'file2.c'])
```

And one with a single file:

```python
Program('hello', 'hello.c')
```

You could actually put a single file name in a list, too, which you might prefer just for the sake of consistency:

```python
Program('hello', ['hello.c'])
```

SCons functions will accept a single file name in either form. In fact, internally, SCons treats all input as lists of files, but allows you to omit the square brackets to cut down a little on the typing when there’s only a single file name.

**Important:** Although SCons functions are forgiving about whether or not you use a string vs. a list for a single file name, Python itself is more strict about treating lists and strings differently. So where SCons allows either a string or list:

```python
# The following two calls both work correctly:
Program('program1', 'program1.c')
Program('program2', ['program2.c'])
```

Trying to do "Python things" that mix strings and lists will cause errors or lead to incorrect results:

```python
common_sources = ['file1.c', 'file2.c']
```
Chapter 3. Less Simple Things to Do With Builds

3.5. Making Lists of Files Easier to Read

One drawback to the use of a Python list for source files is that each file name must be enclosed in quotes (either single quotes or double quotes). This can get cumbersome and difficult to read when the list of file names is long. Fortunately, SCons and Python provide a number of ways to make sure that the SConstruct file stays easy to read.

To make long lists of file names easier to deal with, SCons provides a Split function that takes a quoted list of file names, with the names separated by spaces or other white-space characters, and turns it into a list of separate file names. Using the Split function turns the previous example into:

```python
src_files = Split('main.c file1.c file2.c')
Program('program', src_files)
```

(If you’re already familiar with Python, you’ll have realized that this is similar to the `split()` method in the Python standard string module. Unlike the `string.split()` method, however, the `Split` function does not require a string as input and will wrap up a single non-string object in a list, or return its argument untouched if it’s already a list. This comes in handy as a way to make sure arbitrary values can be passed to SCons functions without having to check the type of the variable by hand.)

Putting the call to the Split function inside the Program call can also be a little unwieldy. A more readable alternative is to assign the output from the Split call to a variable name, and then use the variable when calling the Program function:

```python
src_files = Split('main.c file1.c file2.c')
Program('program', src_files)
```

Lastly, the Split function doesn’t care how much white space separates the file names in the quoted string. This allows you to create lists of file names that span multiple lines, which often makes for easier editing:

```python
src_files = Split('''main.c
file1.c
file2.c''')
```
Chapter 3. Less Simple Things to Do With Builds

Program('program', src_files)

(Note in this example that we used the Python "triple-quote" syntax, which allows a string to contain multiple lines. The three quotes can be either single or double quotes.)

3.6. Keyword Arguments

SCons also allows you to identify the output file and input source files using Python keyword arguments. The output file is known as the target, and the source file(s) are known (logically enough) as the source. The Python syntax for this is:

```python
src_files = Split('main.c file1.c file2.c')
Program(target = 'program', source = src_files)
```

Because the keywords explicitly identify what each argument is, you can actually reverse the order if you prefer:

```python
src_files = Split('main.c file1.c file2.c')
Program(source = src_files, target = 'program')
```

Whether or not you choose to use keyword arguments to identify the target and source files, and the order in which you specify them when using keywords, are purely personal choices; SCons functions the same regardless.

3.7. Compiling Multiple Programs

In order to compile multiple programs within the same SConstruct file, simply call the Program method multiple times, once for each program you need to build:

```python
Program('foo.c')
Program('bar', ['bar1.c', 'bar2.c'])
```

SCons would then build the programs as follows:

```
% scons -Q
cc -o bar1.o -c bar1.c
cc -o bar2.o -c bar2.c
cc -o bar.bar1.o bar2.o
cc -o foo.o -c foo.c
cc -o foo foo.o
```
Notice that SCons does not necessarily build the programs in the same order in which you specify them in the SConstruct file. SCons does, however, recognize that the individual object files must be built before the resulting program can be built. We’ll discuss this in greater detail in the "Dependencies" section, below.

### 3.8. Sharing Source Files Between Multiple Programs

It’s common to re-use code by sharing source files between multiple programs. One way to do this is to create a library from the common source files, which can then be linked into resulting programs. (Creating libraries is discussed in Chapter 4, below.)

A more straightforward, but perhaps less convenient, way to share source files between multiple programs is simply to include the common files in the lists of source files for each program:

```python
Program(Split('foo.c common1.c common2.c'))
Program('bar', Split('bar1.c bar2.c common1.c common2.c'))
```

SCons recognizes that the object files for the `common1.c` and `common2.c` source files each only need to be built once, even though the resulting object files are each linked in to both of the resulting executable programs:

```bash
% scons -Q
cc -o bar1.o -c bar1.c
cc -o bar2.o -c bar2.c
cc -o common1.o -c common1.c
cc -o common2.o -c common2.c
cc -o bar bar1.o bar2.o common1.o common2.o
cc -o foo.o -c foo.c
cc -o foo foo.o common1.o common2.o
```

If two or more programs share a lot of common source files, repeating the common files in the list for each program can be a maintenance problem when you need to change the list of common files. You can simplify this by creating a separate Python list to hold the common file names, and concatenating it with other lists using the Python `+` operator:

```python
common = ['common1.c', 'common2.c']
foo_files = ['foo.c'] + common
bar_files = ['bar1.c', 'bar2.c'] + common
Program('foo', foo_files)
Program('bar', bar_files)
```
Chapter 3. Less Simple Things to Do With Builds

This is functionally equivalent to the previous example.
Chapter 4. Building and Linking with Libraries

It’s often useful to organize large software projects by collecting parts of the software into one or more libraries. SCons makes it easy to create libraries and to use them in the programs.

4.1. Building Libraries

You build your own libraries by specifying `Library` instead of `Program`:

```python
Library('foo', ['f1.c', 'f2.c', 'f3.c'])
```

SCons uses the appropriate library prefix and suffix for your system. So on POSIX or Linux systems, the above example would build as follows (although `ranlib` may not be called on all systems):

```bash
% scons -Q
cc -o f1.o -c f1.c
cc -o f2.o -c f2.c
cc -o f3.o -c f3.c
ar rc libfoo.a f1.o f2.o f3.o
ranlib libfoo.a
```

On a Windows system, a build of the above example would look like:

```bash
C:\>scons -Q
cl /Fof1.obj /c f1.c /nologo
cl /Fof2.obj /c f2.c /nologo
cl /Fof3.obj /c f3.c /nologo
lib /nologo /OUT:foo.lib f1.obj f2.obj f3.obj
```

The rules for the target name of the library are similar to those for programs: if you don’t explicitly specify a target library name, SCons will deduce one from the name of the first source file specified, and SCons will add an appropriate file prefix and suffix if you leave them off.

4.1.1. Building Libraries From Source Code or Object Files

The previous example shows building a library from a list of source files. You can, however, also give the `Library` call object files, and it will correctly realize. In fact, you can arbitrarily mix source code files and object files in the source list:

```python
Library('foo', ['f1.c', 'f2.o', 'f3.c', 'f4.o'])
```
And SCons realizes that only the source code files must be compiled into object files before creating the final library:

```bash
% scons -Q
  cc -o f1.o -c f1.c
  cc -o f3.o -c f3.c
  ar rc libfoo.a f1.o f2.o f3.o f4.o
  ranlib libfoo.a
```

Of course, in this example, the object files must already exist for the build to succeed. See Chapter 5, below, for information about how you can build object files explicitly and include the built files in a library.

### 4.1.2. Building Static Libraries Explicitly: the StaticLibrary Builder

The Library function builds a traditional static library. If you want to be explicit about the type of library being built, you can use the synonym StaticLibrary function instead of Library:

```python
StaticLibrary('foo', ['f1.c', 'f2.c', 'f3.c'])
```

There is no functional difference between the StaticLibrary and Library functions.

### 4.1.3. Building Shared (DLL) Libraries: the SharedLibrary Builder

If you want to build a shared library (on POSIX systems) or a DLL file (on Windows systems), you use the SharedLibrary function:

```python
SharedLibrary('foo', ['f1.c', 'f2.c', 'f3.c'])
```

The output on POSIX:

```bash
% scons -Q
  cc -o f1.os -c f1.c
  cc -o f2.os -c f2.c
  cc -o f3.os -c f3.c
  cc -o libfoo.so -shared f1.os f2.os f3.os
```

And the output on Windows:
Chapter 4. Building and Linking with Libraries

Notice again that SCons takes care of building the output file correctly, adding the \texttt{-shared} option for a POSIX compilation, and the \texttt{/dll} option on Windows.

\section*{4.2. Linking with Libraries}

Usually, you build a library because you want to link it with one or more programs. You link libraries with a program by specifying the libraries in the \texttt{LIBS} construction variable, and by specifying the directory in which the library will be found in the \texttt{LIBPATH} construction variable:

\begin{verbatim}
Library('foo', ['f1.c', 'f2.c', 'f3.c'])
Program('prog.c', LIBS=['foo', 'bar'], LIBPATH='.')
\end{verbatim}

Notice, of course, that you don’t need to specify a library prefix (like \texttt{lib}) or suffix (like \texttt{.a} or \texttt{.lib}). SCons uses the correct prefix or suffix for the current system.

On a POSIX or Linux system, a build of the above example would look like:

\begin{verbatim}
% scons -Q
cc -o f1.o -c f1.c
c -o f2.o -c f2.c
c -o f3.o -c f3.c
ar rc libfoo.a f1.o f2.o f3.o
ranlib libfoo.a
c -o prog.o -c prog.c
c -o prog prog.o -L. -lfoo -lbar
\end{verbatim}

On a Windows system, a build of the above example would look like:

\begin{verbatim}
C:\>scons -Q
c /Fo.f1.obj /c f1.c /nologo
c /Fo.f2.obj /c f2.c /nologo
c /Fo.f3.obj /c f3.c /nologo
lib /nologo /OUT:foo.lib f1.obj f2.obj f3.obj
c /Fo.prog.obj /c prog.c /nologo
link /nologo /OUT:prog.exe /LIBPATH:. foo.lib bar.lib prog.obj
\end{verbatim}
Chapter 4. Building and Linking with Libraries

As usual, notice that SCons has taken care of constructing the correct command lines to link with the specified library on each system.

Note also that, if you only have a single library to link with, you can specify the library name in single string, instead of a Python list, so that:

```python
Program('prog.c', LIBS='foo', LIBPATH='.’)
```

is equivalent to:

```python
Program('prog.c', LIBS=['foo'], LIBPATH='.’)
```

This is similar to the way that SCons handles either a string or a list to specify a single source file.

4.3. Finding Libraries: the $LIBPATH Construction Variable

By default, the linker will only look in certain system-defined directories for libraries. SCons knows how to look for libraries in directories that you specify with the $LIBPATH construction variable. $LIBPATH consists of a list of directory names, like so:

```python
Program('prog.c', LIBS = 'm',
       LIBPATH = ['/usr/lib', '/usr/local/lib'])
```

Using a Python list is preferred because it’s portable across systems. Alternatively, you could put all of the directory names in a single string, separated by the system-specific path separator character: a colon on POSIX systems:

```python
LIBPATH = ’/usr/lib:/usr/local/lib’
```

or a semi-colon on Windows systems:

```python
LIBPATH = ’C:\lib;D:\lib’
```

(Note that Python requires that the backslash separators in a Windows path name be escaped within strings.)
When the linker is executed, SCons will create appropriate flags so that the linker will look for libraries in the same directories as SCons. So on a POSIX or Linux system, a build of the above example would look like:

```
% scons -Q
   cc -o prog.o -c prog.c
   cc -o prog prog.o -L/usr/lib -L/usr/local/lib -lm
```

On a Windows system, a build of the above example would look like:

```
C:\>scons -Q
   cl /Foprog.obj /c prog.c /nologo
   link /nologo /OUT:prog.exe /LIBPATH:\usr\lib /LIBPATH:\usr\local\lib m.lib prog.obj
```

Note again that SCons has taken care of the system-specific details of creating the right command-line options.
Chapter 5. Node Objects

Internally, SCons represents all of the files and directories it knows about as Nodes. These internal objects (not object files) can be used in a variety of ways to make your SConscript files portable and easy to read.

5.1. Builder Methods Return Lists of Target Nodes

All builder methods return a list of Node objects that identify the target file or files that will be built. These returned Nodes can be passed as source files to other builder methods.

For example, suppose that we want to build the two object files that make up a program with different options. This would mean calling the Object builder once for each object file, specifying the desired options:

```python
Object('hello.c', CCFLAGS='-DHELLO')
Object('goodbye.c', CCFLAGS='-DGOODBYE')
```

One way to combine these object files into the resulting program would be to call the Program builder with the names of the object files listed as sources:

```python
Object('hello.c', CCFLAGS='-DHELLO')
Object('goodbye.c', CCFLAGS='-DGOODBYE')
Program(['hello.o', 'goodbye.o'])
```

The problem with listing the names as strings is that our SConstruct file is no longer portable across operating systems. It won’t, for example, work on Windows because the object files there would be named `hello.obj` and `goodbye.obj`, not `hello.o` and `goodbye.o`.

A better solution is to assign the lists of targets returned by the calls to the Object builder to variables, which we can then concatenate in our call to the Program builder:

```python
hello_list = Object('hello.c', CCFLAGS='-DHELLO')
goodbye_list = Object('goodbye.c', CCFLAGS='-DGOODBYE')
Program(hello_list + goodbye_list)
```

This makes our SConstruct file portable again, the build output on Linux looking like:

```
% scons -Q
cc -o goodbye.o -c -DGOODBYE goodbye.c
cc -o hello.o -c -DHELLO hello.c
```
cc -o hello hello.o goodbye.o

And on Windows:
C:\>scons -Q
cl /Fogoodbye.obj /c goodbye.c -DGOODBYE
cl /Fohello.obj /c hello.c -DHELLO
link /nologo /OUT:hello.exe hello.obj goodbye.obj

We’ll see examples of using the list of nodes returned by builder methods throughout the rest of this guide.

5.2. Explicitly Creating File and Directory Nodes

It’s worth mentioning here that SCons maintains a clear distinction between Nodes that represent files and Nodes that represent directories. SCons supports File and Dir functions that, respectively, return a file or directory Node:

```python
hello_c = File(’hello.c’)
Program(hello_c)

classes = Dir(’classes’)
Java(classes, ’src’)
```

Normally, you don’t need to call File or Dir directly, because calling a builder method automatically treats strings as the names of files or directories, and translates them into the Node objects for you. The File and Dir functions can come in handy in situations where you need to explicitly instruct SCons about the type of Node being passed to a builder or other function, or unambiguously refer to a specific file in a directory tree.

There are also times when you may need to refer to an entry in a file system without knowing in advance whether it’s a file or a directory. For those situations, SCons also supports an Entry function, which returns a Node that can represent either a file or a directory:

```python
xyzzy = Entry(’xyzzy’)
```

The returned xyzzy Node will be turned into a file or directory Node the first time it is used by a builder method or other function that requires one vs. the other.
5.3. Printing Node File Names

One of the most common things you can do with a Node is use it to print the file name that the node represents. For example, the following SConstruct file:

```python
hello_c = File('hello.c')
Program(hello_c)

classes = Dir('classes')
Java(classes, 'src')

object_list = Object('hello.c')
program_list = Program(object_list)
print "The object file is: ", object_list[0]
print "The program file is: ", program_list[0]
```

Would print the following file names on a POSIX system:

```
% scons -Q
The object file is: hello.o
The program file is: hello
cc -o hello.o -c hello.c
cc -o hello hello.o
```

And the following file names on a Windows system:

```
C:\>scons -Q
The object file is: hello.obj
The program file is: hello.exe
cl /Fohello.obj /c hello.c /nologo
link /nologo /OUT:hello.exe hello.obj
```

5.4. Using a Node’s File Name as a String

Printing a Node’s name as described in the previous section works because the string representation of a Node is the name of the file. If you want to do something other than print the name of the file, you can fetch it by using the built-in Python `str` function. For example, if you want to use the Python `os.path.exists` to figure out whether a file exists while the SConstruct file is being read and executed, you can fetch the string as follows:

```python
import os.path
program_list = Program('hello.c')
program_name = str(program_list[0])
if not os.path.exists(program_name):
```
print program_name, "does not exist!"

Which executes as follows on a POSIX system:

% scons -Q
hello does not exist!
cc -o hello.o -c hello.c
cc -o hello hello.o
Chapter 6. Dependencies

So far we’ve seen how SCons handles one-time builds. But one of the main functions of a build tool like SCons is to rebuild only the necessary things when source files change—or, put another way, SCons should not waste time rebuilding things that have already been built. You can see this at work simply by re-invoking SCons after building our simple hello example:

```bash
% scons -Q
cc -o hello.o -c hello.c
cc -o hello hello.o
% scons -Q
scons: `.' is up to date.
```

The second time it is executed, SCons realizes that the hello program is up-to-date with respect to the current hello.c source file, and avoids rebuilding it. You can see this more clearly by naming the hello program explicitly on the command line:

```bash
% scons -Q hello
cc -o hello.o -c hello.c
cc -o hello hello.o
% scons -Q hello
scons: `hello’ is up to date.
```

Note that SCons reports "...is up to date" only for target files named explicitly on the command line, to avoid cluttering the output.

6.1. Deciding When an Input File Has Changed: the Decider Function

Another aspect of avoiding unnecessary rebuilds is the fundamental build tool behavior of rebuilding things when an input file changes, so that the built software is up to date. By default, SCons keeps track of this through an MD5 signature, or checksum, of the contents of each file, although you can easily configure SCons to use the modification times (or time stamps) instead. You can even specify your own Python function for deciding if an input file has changed.

6.1.1. Using MD5 Signatures to Decide if a File Has Changed

By default, SCons keeps track of whether a file has changed based on an MD5 checksum of the file’s contents, not the file’s modification time. This means that you may be surprised by the default SCons behavior if you are used to the Make convention of forcing a rebuild by updating the file’s modification time (using the touch command, for example):
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% scons -Q hello
cc -o hello.o -c hello.c
cc -o hello hello.o
% touch hello.c
% scons -Q hello
scons: 'hello' is up to date.

Even though the file's modification time has changed, SCons realizes that the contents of the hello.c file have not changed, and therefore that the hello program need not be rebuilt. This avoids unnecessary rebuilds when, for example, someone rewrites the contents of a file without making a change. But if the contents of the file really do change, then SCons detects the change and rebuilds the program as required:

% scons -Q hello
cc -o hello.o -c hello.c
cc -o hello hello.o
% edit hello.c
   [CHANGE THE CONTENTS OF hello.c]
% scons -Q hello
cc -o hello.o -c hello.c
cc -o hello hello.o

Note that you can, if you wish, specify this default behavior (MD5 signatures) explicitly using the Decider function as follows:

    Program('hello.c')
    Decider('MD5')

You can also use the string 'content' as a synonym for 'MD5' when calling the Decider function.

6.1.1.1. Ramifications of Using MD5 Signatures

Using MD5 Signatures to decide if an input file has changed has one surprising benefit: if a source file has been changed in such a way that the contents of the rebuilt target file(s) will be exactly the same as the last time the file was built, then any "downstream" target files that depend on the rebuilt-but-not-changed target file actually need not be rebuilt.

So if, for example, a user were to only change a comment in a hello.c file, then the rebuilt hello.o file would be exactly the same as the one previously built (assuming the compiler doesn't put any build-specific information in the object file). SCons would then realize that it would not need to rebuild the hello program as follows:

% scons -Q hello
cc -o hello.o -c hello.c
cc -o hello hello.o
In essence, SCons "short-circuits" any dependent builds when it realizes that a target file has been rebuilt to exactly the same file as the last build. This does take some extra processing time to read the contents of the target (hello.o) file, but often saves time when the rebuild that was avoided would have been time-consuming and expensive.

### 6.1.2. Using Time Stamps to Decide If a File Has Changed

If you prefer, you can configure SCons to use the modification time of a file, not the file contents, when deciding if a target needs to be rebuilt. SCons gives you two ways to use time stamps to decide if an input file has changed since the last time a target has been built.

The most familiar way to use time stamps is the way Make does: that is, have SCons decide and target must be rebuilt if if a source file’s modification time is newer than the target file. To do this, call the Decider function as follows:

```python
Program('hello.c')
Decider('timestamp-newer')
```

This makes SCons act like Make when a file’s modification time is updated (using the touch command, for example):

```bash
% scons -Q hello
cc -o hello.o -c hello.c
cc -o hello hello.o
% touch hello.c
% scons -Q hello
cc -o hello.o -c hello.c
cc -o hello hello.o
```

And, in fact, because this behavior is the same as the behavior of Make, you can also use the string 'make' as a synonym for 'timestamp-newer' when calling the Decider function:

```python
Program('hello.c')
Decider('make')
```
One drawback to using times stamps exactly like Make is that if an input file’s modification time suddenly becomes older than a target file, the target file will not be rebuilt. This can happen if an old copy of a source file is restored from a backup archive, for example. The contents of the restored file will likely be different than they were the last time a dependent target was built, but the target won’t be rebuilt because the modification time of the source file is not newer than the target.

Because SCons actually stores information about the source files’ time stamps whenever a target is built, it can handle this situation by checking for an exact match of the source file time stamp, instead of just whether or not the source file is newer than the target file. To do this, specify the argument ‘timestamp-match’ when calling the Decider function:

```python
Program('hello.c')
Decider('timestamp-match')
```

When configured this way, SCons will rebuild a target whenever a source file’s modification time has changed. So if we use the `touch -t` option to change the modification time of `hello.c` to an old date (January 1, 1989), SCons will still rebuild the target file:

```
% scons -Q hello
cc -o hello.o -c hello.c
cc -o hello hello.o
% touch -t 198901010000 hello.c
% scons -Q hello
cc -o hello.o -c hello.c
scons: 'hello' is up to date.
```

In general, the only reason to prefer `timestamp-newer` instead of `timestamp-match`, would be if you have some specific reason to require this Make-like behavior of not rebuilding a target when an otherwise-modified source file is older.

### 6.1.3. Deciding If a File Has Changed Using Both MD Signatures and Time Stamps

As a performance enhancement, SCons provides a way to use MD5 checksums of file contents but to only read the contents whenever the file’s timestamp has changed. To do this, call the Decider function with ‘MD5-timestamp’ argument as follows:

```python
Program('hello.c')
Decider('MD5-timestamp')
```

So configured, SCons will still behave like it does when using `Decider('MD5')`:

```
% scons -Q hello
```
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```plaintext
cc -o hello.o -c hello.c
cc -o hello hello.o
% touch hello.c
% scons -Q hello
scons: 'hello' is up to date.
% edit hello.c
   [CHANGE THE CONTENTS OF hello.c]
% scons -Q hello
cc -o hello.o -c hello.c
cc -o hello hello.o
```

However, the second call to SCons in the above output, when the build is up-to-date, will have been performed by simply looking at the modification time of the `hello.c` file, not by opening it and performing an MD5 checksum calculation on its contents. This can significantly speed up many up-to-date builds.

The only drawback to using `Decider('MD5-timestamp')` is that SCons will not rebuild a target file if a source file was modified within one second of the last time SCons built the file. While most developers are programming, this isn’t a problem in practice, since it’s unlikely that someone will have built and then thought quickly enough to make a substantive change to a source file within one second. Certain build scripts or continuous integration tools may, however, rely on the ability to applying changes to files automatically and then rebuild as quickly as possible, in which case use of `Decider('MD5-timestamp')` may not be appropriate.

### 6.1.4. Writing Your Own Custom Decider Function

The different string values that we’ve passed to the `Decider` function are essentially used by SCons to pick one of several specific internal functions that implement various ways of deciding if a dependency (usually a source file) has changed since a target file has been built. As it turns out, you can also supply your own function to decide if a dependency has changed.

For example, suppose we have an input file that contains a lot of data, in some specific regular format, that is used to rebuild a lot of different target files, but each target file really only depends on one particular section of the input file. We’d like to have each target file depend on only its section of the input file. However, since the input file may contain a lot of data, we only want to open the input file if its timestamp has changed. This could be done with a custom `Decider` function that might look something like this:

```python
Program('hello.c')
def decide_if_changed(dependency, target, prev_ni):
    if self.get_timestamp() != prev_ni.timestamp:
        dep = str(dependency)
        tgt = str(target)
        if specific_part_of_file_has_changed(dep, tgt):
            return True
```

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Note that in the function definition, the dependency (input file) is the first argument, and then the target. Both of these are passed to the functions as SCons Node objects, which we convert to strings using the Python `str()`.

The third argument, `prev_ni`, is an object that holds the signature or timestamp information that was recorded about the dependency the last time the target was built. A `prev_ni` object can hold different information, depending on the type of thing that the dependency argument represents. For normal files, the `prev_ni` object has the following attributes:

- `.csig`
  - The content signature, or MD5 checksum, of the contents of the dependency file the list time the target was built.
- `.size`
  - The size in bytes of the dependency file the list time the target was built.
- `.timestamp`
  - The modification time of the dependency file the list time the target was built.

Note that ignoring some of the arguments in your custom `Decider` function is a perfectly normal thing to do, if they don’t impact the way you want to decide if the dependency file has changed.

### 6.1.5. Mixing Different Ways of Deciding If a File Has Changed

The previous examples have all demonstrated calling the global `Decider` function to configure all dependency decisions that SCons makes. Sometimes, however, you want to be able to configure different decision-making for different targets. When that’s necessary, you can use the `env.Decider` method to affect only the configuration decisions for targets built with a specific construction environment.

For example, if we arbitrarily want to build one program using MD5 checkums and another use file modification times from the same source we might configure it this way:

```python
env1 = Environment(CPPPATH = ['.'])
env2 = env1.Clone()
env2.Decider('timestamp-match')
env1.Program('prog-MD5', 'program1.c')
env2.Program('prog-timestamp', 'program2.c')
```
If both of the programs include the same inc.h file, then updating the modification time of inc.h (using the touch command) will cause only prog-timestamp to be rebuilt:

```
% scons -Q
cc -o program1.o -c -I. program1.c
cc -o prog-MD5 program1.o
cc -o program2.o -c -I. program2.c
cc -o prog-timestamp program2.o
% touch inc.h
% scons -Q
cc -o program2.o -c -I. program2.c
cc -o prog-timestamp program2.o
```

6.2. Older Functions for Deciding When an Input File Has Changed

SCons still supports two functions that used to be the primary methods for configuring the decision about whether or not an input file has changed. Although they’re not officially deprecated yet, their use is discouraged, mainly because they rely on a somewhat confusing distinction between how source files and target files are handled. These functions are documented here mainly in case you encounter them in existing SConscript files.

6.2.1. The SourceSignatures Function

The SourceSignatures function is fairly straightforward, and supports two different argument values to configure whether source file changes should be decided using MD5 signatures:

```
Program('hello.c')
SourceSignatures('MD5')
```

Or using time stamps:

```
Program('hello.c')
SourceSignatures('timestamp')
```

These are roughly equivalent to specifying Decider('MD5') or Decider('timestamp-match'), respectively, although it only affects how SCons makes decisions about dependencies on *source* files—that is, files that are not built from any other files.
6.2.2. The TargetSignatures Function

The TargetSignatures function specifies how SCons decides when a target file has changed when it is used as a dependency of (input to) another target--that is, the TargetSignatures function configures how the signatures of "intermediate" target files are used when deciding if a "downstream" target file must be rebuilt. ¹

The TargetSignatures function supports the same ‘MD5’ and ‘timestamp’ argument values that are supported by the SourceSignatures, with the same meanings, but applied to target files. That is, in the example:

```python
Program('hello.c')
TargetSignatures('MD5')
```

The MD5 checksum of the hello.o target file will be used to decide if it has changed since the last time the "downstream" hello target file was built. And in the example:

```python
Program('hello.c')
TargetSignatures('timestamp')
```

The modification time of the hello.o target file will be used to decide if it has changed since the last time the "downstream" hello target file was built.

The TargetSignatures function supports two additional argument values: ‘source’ and ‘build’. The ‘source’ argument specifies that decisions involving whether target files have changed since a previous build should use the same behavior for the decisions configured for source files (using the SourceSignatures function). So in the example:

```python
Program('hello.c')
TargetSignatures('source')
SourceSignatures('timestamp')
```

All files, both targets and sources, will use modification times when deciding if an input file has changed since the last time a target was built.

Lastly, the ‘build’ argument specifies that SCons should examine the build status of a target file and always rebuild a "downstream" target if the target file was itself rebuilt, without re-examining the contents or timestamp of the newly-built target file. If the target file was not rebuilt during this scons invocation, then the target file will be examined the same way as configured by the SourceSignature call to decide if it has changed.
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This mimics the behavior of build signatures in earlier versions of SCons. A build signature re-combined signatures of all the input files that went into making the target file, so that the target file itself did not need to have its contents read to compute an MD5 signature. This can improve performance for some configurations, but is generally not as effective as using Decider('MD5-timestamp').

6.3. Implicit Dependencies: The $CPPPATH Construction Variable

Now suppose that our "Hello, World!" program actually has an #include line to include the hello.h file in the compilation:

```c
#include <hello.h>
int
main()
{
    printf("Hello, %s
", string);
}
```

And, for completeness, the hello.h file looks like this:

```c
#define string   "world"
```

In this case, we want SCons to recognize that, if the contents of the hello.h file change, the hello program must be recompiled. To do this, we need to modify the SConstruct file like so:

```python
Program('hello.c', CPPPATH = '.')
```

The $CPPPATH value tells SCons to look in the current directory ('.') for any files included by C source files (.c or .h files). With this assignment in the SConstruct file:

```bash
% scons -Q hello
c -o hello.o -c -I. hello.c
c -o hello hello.o
% scons -Q hello
scons: 'hello' is up to date.
% edit hello.h
    [CHANGE THE CONTENTS OF hello.h]
% scons -Q hello
c -o hello.o -c -I. hello.c
c -o hello hello.o
```
First, notice that SCons added the `-I` argument from the `$CPPPATH` variable so that the compilation would find the `hello.h` file in the local directory.

Second, realize that SCons knows that the hello program must be rebuilt because it scans the contents of the `hello.c` file for the `#include` lines that indicate another file is being included in the compilation. SCons records these as implicit dependencies of the target file. Consequently, when the `hello.h` file changes, SCons realizes that the `hello.c` file includes it, and rebuilds the resulting hello program that depends on both the `hello.c` and `hello.h` files.

Like the `$LIBPATH` variable, the `$CPPPATH` variable may be a list of directories, or a string separated by the system-specific path separation character (`:' on POSIX/Linux, ';' on Windows). Either way, SCons creates the right command-line options so that the following example:

```
Program('hello.c', CPPPATH = ['include', '/home/project/inc'])
```

Will look like this on POSIX or Linux:

```
% scons -Q hello
cc -o hello.o -c -Iinclude -I/home/project/inc hello.c
cc -o hello hello.o
```

And like this on Windows:

```
C:\>scons -Q hello.exe
cl /Fohello.obj /c hello.c /nologo /Iinclude /I\home\project\inc
link /nologo /OUT:hello.exe hello.obj
```

### 6.4. Caching Implicit Dependencies

Scanning each file for `#include` lines does take some extra processing time. When you’re doing a full build of a large system, the scanning time is usually a very small percentage of the overall time spent on the build. You’re most likely to notice the scanning time, however, when you rebuild all or part of a large system: SCons will likely take some extra time to "think about" what must be built before it issues the first build command (or decides that everything is up to date and nothing must be rebuilt).

In practice, having SCons scan files saves time relative to the amount of potential time lost to tracking down subtle problems introduced by incorrect dependencies. Nevertheless, the "waiting time" while SCons scans files can annoy individual developers waiting for their builds to finish. Consequently, SCons lets you cache the implicit dependencies that its scanners find, for use by later builds. You can do this by specifying the `--implicit-cache` option on the command line:
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% scons -Q --implicit-cache hello
cc -o hello.o -c hello.c
c -o hello hello.o
% scons -Q hello
scons: 'hello' is up to date.

If you don’t want to specify --implicit-cache on the command line each time, you can make it the default behavior for your build by setting the implicit_cache option in an SConscript file:

SetOption('implicit_cache', 1)

SCons does not cache implicit dependencies like this by default because the --implicit-cache causes SCons to simply use the implicit dependencies stored during the last run, without any checking for whether or not those dependencies are still correct. Specifically, this means --implicit-cache instructs SCons to not rebuild "correctly" in the following cases:

• When --implicit-cache is used, SCons will ignore any changes that may have been made to search paths (like $CPPPATH or $LIBPATH,). This can lead to SCons not rebuilding a file if a change to SCPPPATH would normally cause a different, same-named file from a different directory to be used.
• When --implicit-cache is used, SCons will not detect if a same-named file has been added to a directory that is earlier in the search path than the directory in which the file was found last time.

6.4.1. The --implicit-deps-changed Option

When using cached implicit dependencies, sometimes you want to "start fresh" and have SCons re-scan the files for which it previously cached the dependencies. For example, if you have recently installed a new version of external code that you use for compilation, the external header files will have changed and the previously-cached implicit dependencies will be out of date. You can update them by running SCons with the --implicit-deps-changed option:

% scons -Q --implicit-deps-changed hello
cc -o hello.o -c hello.c
c -o hello hello.o
% scons -Q hello
scons: 'hello' is up to date.

In this case, SCons will re-scan all of the implicit dependencies and cache updated copies of the information.
6.4.2. The `--implicit-deps-unchanged` Option

By default when caching dependencies, SCons notices when a file has been modified and re-scans the file for any updated implicit dependency information. Sometimes, however, you may want to force SCons to use the cached implicit dependencies, even if the source files changed. This can speed up a build for example, when you have changed your source files but know that you haven’t changed any `#include` lines. In this case, you can use the `--implicit-deps-unchanged` option:

```
% scons -Q --implicit-deps-unchanged hello
cc -o hello.o -c hello.c
cc -o hello hello.o
% scons -Q hello
scons: 'hello' is up to date.
```

In this case, SCons will assume that the cached implicit dependencies are correct and will not bother to re-scan changed files. For typical builds after small, incremental changes to source files, the savings may not be very big, but sometimes every bit of improved performance counts.

6.5. Explicit Dependencies: the `Depends` Function

Sometimes a file depends on another file that is not detected by an SCons scanner. For this situation, SCons allows you to specify explicitly that one file depends on another file, and must be rebuilt whenever that file changes. This is specified using the `Depends` method:

```
hello = Program('hello.c')
Depends(hello, 'other_file')
```

```
% scons -Q hello
cc -c hello.c -o hello.o
cc -o hello hello.o
% scons -Q hello
scons: 'hello' is up to date.
% edit other_file
[CHANGE THE CONTENTS OF other_file]
% scons -Q hello
cc -c hello.c -o hello.o
cc -o hello hello.o
```

Note that the dependency (the second argument to `Depends`) may also be a list of Node objects (for example, as returned by a call to a Builder):

```
hello = Program('hello.c')
goodbye = Program('goodbye.c')
```
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Depends(hello, goodbye)

in which case the dependency or dependencies will be built before the target(s):

% scons -Q hello
cc -c goodbye.c -o goodbye.o
cc -o goodbye goodbye.o
cc -c hello.c -o hello.o
cc -o hello hello.o

6.6. Dependencies From External Files: the ParseDepends Function

SCons has built-in scanners for a number of languages. Sometimes these scanners fail to extract certain implicit dependencies due to limitations of the scanner implementation.

The following example illustrates a case where the built-in C scanner is unable to extract the implicit dependency on a header file.

```plaintext
#define FOO_HEADER <foo.h>
#include FOO_HEADER

int main() {
    return FOO;
}

% scons -Q
cc -o hello.o -c -I. hello.c
cc -o hello hello.o
% edit foo.h
  [CHANGE CONTENTS OF foo.h]
% scons -Q
scons: '.' is up to date.
```

Apparently, the scanner does not know about the header dependency. Being not a full-fledged C preprocessor, the scanner does not expand the macro.

In these cases, you may also use the compiler to extract the implicit dependencies. ParseDepends can parse the contents of the compiler output in the style of Make, and explicitly establish all of the listed dependencies.
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The following example uses ParseDepends to process a compiler generated dependency file which is generated as a side effect during compilation of the object file:

```python
obj = Object('hello.c', CCFLAGS='-MD -MF hello.d', CPPPATH='.')
SideEffect('hello.d', obj)
ParseDepends('hello.d')
Program('hello', obj)
```

```bash
% scons -Q
cc -o hello.o -c -MD -MF hello.d -I. hello.c
cc -o hello hello.o
% edit foo.h
  [CHANGE CONTENTS OF foo.h]
% scons -Q
cc -o hello.o -c -MD -MF hello.d -I. hello.c
```

Parsing dependencies from a compiler-generated `.d` file has a chicken-and-egg problem, that causes unnecessary rebuilds:

```bash
% scons -Q
cc -o hello.o -c -MD -MF hello.d -I. hello.c
cc -o hello hello.o
% scons -Q --debug=explain
scons: rebuilding 'hello.o' because 'foo.h' is a new dependency
cc -o hello.o -c -MD -MF hello.d -I. hello.c
% scons -Q
scons: '.' is up to date.
```

In the first pass, the dependency file is generated while the object file is compiled. At that time, SCons does not know about the dependency on `foo.h`. In the second pass, the object file is regenerated because `foo.h` is detected as a new dependency.

ParseDepends immediately reads the specified file at invocation time and just returns if the file does not exist. A dependency file generated during the build process is not automatically parsed again. Hence, the compiler-extracted dependencies are not stored in the signature database during the same build pass. This limitation of ParseDepends leads to unnecessary recompilations. Therefore, ParseDepends should only be used if scanners are not available for the employed language or not powerful enough for the specific task.

### 6.7. Ignoring Dependencies: the Ignore Function

Sometimes it makes sense to not rebuild a program, even if a dependency file changes. In this case, you would tell SCons specifically to ignore a dependency as follows:
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```python
hello = Program('hello.c')
Ignore(hello, 'hello.h')

% scons -Q hello
cc -c -o hello.o hello.c
cc -o hello hello.o
% scons -Q hello
scons: 'hello' is up to date.
% edit hello.h
  [CHANGE THE CONTENTS OF hello.h]
% scons -Q hello
scons: 'hello' is up to date.
```

Now, the above example is a little contrived, because it’s hard to imagine a real-world situation where you wouldn’t want to rebuild hello if the hello.h file changed. A more realistic example might be if the hello program is being built in a directory that is shared between multiple systems that have different copies of the stdio.h include file. In that case, SCons would notice the differences between the different systems’ copies of stdio.h and would rebuild hello each time you change systems. You could avoid these rebuilds as follows:

```python
hello = Program('hello.c', CPPPATH=['/usr/include'])
Ignore(hello, '/usr/include/stdio.h')
```

Ignore can also be used to prevent a generated file from being built by default. This is due to the fact that directories depend on their contents. So to ignore a generated file from the default build, you specify that the directory should ignore the generated file. Note that the file will still be built if the user specifically requests the target on scons command line, or if the file is a dependency of another file which is requested and/or is built by default.

```python
hello_obj=Object('hello.c')
hello = Program(hello_obj)
Ignore('.', [hello, hello_obj])

% scons -Q
scons: '.' is up to date.
% scons -Q hello
cc -o hello.o -c hello.c
cc -o hello hello.o
% scons -Q hello
scons: 'hello' is up to date.
```
6.8. Order-Only Dependencies: the `Requires` Function

Occasionally, it may be useful to specify that a certain file or directory must, if necessary, be built or created before some other target is built, but that changes to that file or directory do not require that the target itself be rebuilt. Such a relationship is called an *order-only dependency* because it only affects the order in which things must be built—the dependency before the target—but it is not a strict dependency relationship because the target should not change in response to changes in the dependent file.

For example, suppose that you want to create a file every time you run a build that identifies the time the build was performed, the version number, etc., and which is included in every program that you build. The version file’s contents will change every build. If you specify a normal dependency relationship, then every program that depends on that file would be rebuilt every time you run SCons. For example, we could use some Python code in a `SConstruct` file to create a new `version.c` file with a string containing the current date every time we run SCons, and then link a program with the resulting object file by listing `version.c` in the sources:

```python
import time

version_c_text = "\nchar *date = "%s"; \n\n" % time.ctime(time.time())
open('version.c', 'w').write(version_c_text)

hello = Program(['hello.c', 'version.c'])
```

If we list `version.c` as an actual source file, though, then `version.o` will get rebuilt every time we run SCons (because the `SConstruct` file itself changes the contents of `version.c`) and the `hello` executable will get re-linked every time (because the `version.o` file changes):

```
% scons -Q
gcc -o hello.o -c hello.c
gcc -o version.o -c version.c
gcc -o hello hello.o version.o
% scons -Q
gcc -o version.o -c version.c
gcc -o hello hello.o version.o
% scons -Q
gcc -o version.o -c version.c
gcc -o hello hello.o version.o
```

One solution is to use the `Requires` function to specify that the `version.o` must be rebuilt before it is used by the link step, but that changes to `version.o` should not actually cause the `hello` executable to be re-linked:

```python
import time
```
version_c_text = ""
char *date = "%s";
""
    % time.ctime(time.time())
open('version.c', 'w').write(version_c_text)

version_obj = Object('version.c')

hello = Program('hello.c',
    LINKFLAGS = str(version_obj[0]))

Requires(hello, version_obj)

Notice that because we can no longer list version.c as one of the sources for the hello program, we have to find some other way to get it into the link command line. For this example, we’re cheating a bit and stuffing the object file name (extracted from version_obj list returned by the Object call) into the $LINKFLAGS variable, because $LINKFLAGS is already included in the $LINKCOM command line.

With these changes, we get the desired behavior of re-building the version.o file, and therefore re-linking the hello executable, only when the hello.c has changed:

```
% scons -Q
c -o hello.o -c hello.c
c -o version.o -c version.c
c -o hello version.o hello.o
% scons -Q
scons: '.' is up to date.
% edit hello.c
[CHANGE THE CONTENTS OF hello.c]
% scons -Q
c -o hello.o -c hello.c
c -o hello version.o hello.o
% scons -Q
scons: '.' is up to date.
```

### 6.9. The `AlwaysBuild` Function

How SCons handles dependencies can also be affected by the `AlwaysBuild` method. When a file is passed to the `AlwaysBuild` method, like so:

```python
hello = Program('hello.c')
AlwaysBuild(hello)
```

Then the specified target file (hello in our example) will always be considered out-of-date and rebuilt whenever that target file is evaluated while walking the dependency graph:
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```
% scons -Q
cc -o hello.o -c hello.c
cc -o hello hello.o
% scons -Q
cc -o hello hello.o
```

The `AlwaysBuild` function has a somewhat misleading name, because it does not actually mean the target file will be rebuilt every single time SCons is invoked. Instead, it means that the target will, in fact, be rebuilt whenever the target file is encountered while evaluating the targets specified on the command line (and their dependencies). So specifying some other target on the command line, a target that does not itself depend on the `AlwaysBuild` target, will still be rebuilt only if it’s out-of-date with respect to its dependencies:

```
% scons -Q
cc -o hello.o -c hello.c
cc -o hello hello.o
% scons -Q hello.o
scons: 'hello.o' is up to date.
```

**Notes**

1. This easily-overlooked distinction between how SCons decides if the target itself must be rebuilt and how the target is then used to decide if a different target must be rebuilt is one of the confusing things that has led to the `TargetSignatures` and `SourceSignatures` functions being replaced by the simpler `Decider` function.
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An environment is a collection of values that can affect how a program executes. SCons distinguishes between three different types of environments that can affect the behavior of SCons itself (subject to the configuration in the SConscript files), as well as the compilers and other tools it executes:

External Environment

The external environment is the set of variables in the user’s environment at the time the user runs SCons. These variables are available within the SConscript files through the Python os.environ dictionary. See Section 7.1, below.

Construction Environment

A construction environment is a distinct object creating within a SConscript file and which contains values that affect how SCons decides what action to use to build a target, and even to define which targets should be built from which sources. One of the most powerful features of SCons is the ability to create multiple construction environments, including the ability to clone a new, customized construction environment from an existing construction environment. See Section 7.2, below.

Execution Environment

An execution environment is the values that SCons sets when executing an external command (such as a compiler or linker) to build one or more targets. Note that this is not the same as the external environment (see above). See Section 7.3, below.

Unlike Make, SCons does not automatically copy or import values between different environments (with the exception of explicit clones of construction environments, which inherit values from their parent). This is a deliberate design choice to make sure that builds are, by default, repeatable regardless of the values in the user’s external environment. This avoids a whole class of problems with builds where a developer’s local build works because a custom variable setting causes a different compiler or build option to be used, but the checked-in change breaks the official build because it uses different environment variable settings.

Note that the SConscript writer can easily arrange for variables to be copied or imported between environments, and this is often very useful (or even downright necessary) to make it easy for developers to customize the build in appropriate ways. The point is not that copying variables between different environments is evil and must always be avoided. Instead, it should be up to the implementer of the build system to make conscious choices about how and when to import a variable from one environment to another, making informed decisions about striking the right balance between making the build repeatable on the one hand and convenient to use on the other.
7.1. Using Values From the External Environment

The external environment variable settings that the user has in force when executing SCons are available through the normal Python os.environ dictionary. This means that you must add an import os statement to any SConscript file in which you want to use values from the user’s external environment.

```python
import os
```

More usefully, you can use the os.environ dictionary in your SConscript files to initialize construction environments with values from the user’s external environment. See the next section, Section 7.2, for information on how to do this.

7.2. Construction Environments

It is rare that all of the software in a large, complicated system needs to be built the same way. For example, different source files may need different options enabled on the command line, or different executable programs need to be linked with different libraries. SCons accommodates these different build requirements by allowing you to create and configure multiple construction environments that control how the software is built. A construction environment is an object that has a number of associated construction variables, each with a name and a value. (A construction environment also has an attached set of Builder methods, about which we’ll learn more later.)

7.2.1. Creating a Construction Environment: the Environment Function

A construction environment is created by the Environment method:

```python
env = Environment()
```

By default, SCons initializes every new construction environment with a set of construction variables based on the tools that it finds on your system, plus the default set of builder methods necessary for using those tools. The construction variables are initialized with values describing the C compiler, the Fortran compiler, the linker, etc., as well as the command lines to invoke them.

When you initialize a construction environment you can set the values of the environment’s construction variables to control how a program is built. For example:

```python
import os

env = Environment(CC = 'gcc',
```
The construction environment in this example is still initialized with the same default construction variable values, except that the user has explicitly specified use of the GNU C compiler gcc, and further specifies that the `-O2` (optimization level two) flag should be used when compiling the object file. In other words, the explicit initializations of `$CC` and `$CCFLAGS` override the default values in the newly-created construction environment. So a run from this example would look like:

```
% scons -Q
gcc -o foo.o -c -O2 foo.c
gcc -o foo foo.o
```

### 7.2.2. Fetching Values From a Construction Environment

You can fetch individual construction variables using the normal syntax for accessing individual named items in a Python dictionary:

```python
env = Environment()
print "CC is: ", env['CC']
```

This example `SConstruct` file doesn’t build anything, but because it’s actually a Python script, it will print the value of `$CC` for us:

```
% scons -Q
CC is: cc
scons: '.' is up to date.
```

A construction environment, however, is actually an object with associated methods, etc. If you want to have direct access to only the dictionary of construction variables, you can fetch this using the `Dictionary` method:

```python
env = Environment(FOO = 'foo', BAR = 'bar')
dict = env.Dictionary()
for key in ['OBJSUFFIX', 'LIBSUFFIX', 'PROGSUFFIX']:
    print "key = %s, value = %s" % (key, dict[key])
```

This `SConstruct` file will print the specified dictionary items for us on POSIX systems as follows:

```
% scons -Q
```
key = OBJSUFFIX, value = .o
key = LIBSUFFIX, value = .a
key = PROGSUFFIX, value =
scons: '.' is up to date.

And on Windows:

C:\>scons -Q
key = OBJSUFFIX, value = .obj
key = LIBSUFFIX, value = .lib
key = PROGSUFFIX, value = .exe
scons: '.' is up to date.

If you want to loop and print the values of all of the construction variables in a construction environment, the Python code to do that in sorted order might look something like:

```python
env = Environment()
dict = env.Dictionary()
keys = dict.keys()
keys.sort()
for key in keys:
    print "construction variable = '%s', value = '%s'" % (key, dict[key])
```

### 7.2.3. Expanding Values From a Construction Environment: the `subst` Method

Another way to get information from a construction environment, is to use the `subst` method on a string containing $ expansions of construction variable names. As a simple example, the example from the previous section that used `env['CC']` to fetch the value of `$CC` could also be written as:

```python
env = Environment()
print "CC is:", env.subst('$_CC')
```

One advantage of using `subst` to expand strings is that construction variables in the result get re-expanded until there are no expansions left in the string. So a simple fetch of a value like `$CCCOM`:

```python
env = Environment(CCFLAGS = '-DFOO')
print "CCCOM is:", env['CCCOM']
```

Will print the unexpanded value of `$CCCOM`, showing us the construction variables that still need to be expanded:
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% scons -Q
CCCOM is: $CC $CCFLAGS $CPPFLAGS $_CPPDEFFLAGS $_CPPINCFLAGS -c -o $TARGET $SOURCES
scons: '.' is up to date.

Calling the subst method on $CCOM, however:

```python
env = Environment(CCFLAGS = '-DFOO')
print "CCCOM is:", env.subst('$$CCCOM')
```

Will recursively expand all of the construction variables prefixed with $ (dollar signs), showing us the final output:

% scons -Q
CCCOM is: gcc -DFOO -c -o
scons: '.' is up to date.

Note that because we’re not expanding this in the context of building something there are no target or source files for $TARGET and $SOURCES to expand.

7.2.4. Controlling the Default Construction Environment: the DefaultEnvironment Function

All of the Builder functions that we’ve introduced so far, like Program and Library, actually use a default construction environment that contains settings for the various compilers and other tools that SCons configures by default, or otherwise knows about and has discovered on your system. The goal of the default construction environment is to make many configurations to "just work" to build software using readily available tools with a minimum of configuration changes.

You can, however, control the settings in the default construction environment by using the DefaultEnvironment function to initialize various settings:

```python
DefaultEnvironment(CC = ‘/usr/local/bin/gcc’)
```

When configured as above, all calls to the Program or Object Builder will build object files with the /usr/local/bin/gcc compiler.

Note that the DefaultEnvironment function returns the initialized default construction environment object, which can then be manipulated like any other construction environment. So the following would
be equivalent to the previous example, setting the $CC variable to /usr/local/bin/gcc but as a separate step after the default construction environment has been initialized:

```python
env = DefaultEnvironment()
env['CC'] = '/usr/local/bin/gcc'
```

One very common use of the `DefaultEnvironment` function is to speed up SCons initialization. As part of trying to make most default configurations "just work," SCons will actually search the local system for installed compilers and other utilities. This search can take time, especially on systems with slow or networked file systems. If you know which compiler(s) and/or other utilities you want to configure, you can control the search that SCons performs by specifying some specific tool modules with which to initialize the default construction environment:

```python
env = DefaultEnvironment(tools = ['gcc', 'gnulink'],
                        CC = '/usr/local/bin/gcc')
```

So the above example would tell SCons to explicitly configure the default environment to use its normal GNU Compiler and GNU Linker settings (without having to search for them, or any other utilities for that matter), and specifically to use the compiler found at /usr/local/bin/gcc.

### 7.2.5. Multiple Construction Environments

The real advantage of construction environments is that you can create as many different construction environments as you need, each tailored to a different way to build some piece of software or other file. If, for example, we need to build one program with the `-O2` flag and another with the `-g` (debug) flag, we would do this like so:

```python
opt = Environment(CCFLAGS = '-O2')
dbg = Environment(CCFLAGS = '-g')

opt.Program('foo', 'foo.c')
dbg.Program('bar', 'bar.c')
```

```sh
% scons -Q
cc -o bar.o -c -g bar.c
c -o bar bar.o
c -o foo.o -c -O2 foo.c
c -o foo foo.o
```
We can even use multiple construction environments to build multiple versions of a single program. If you do this by simply trying to use the `Program` builder with both environments, though, like this:

```python
opt = Environment(CCFLAGS = '-O2')
dbg = Environment(CCFLAGS = '-g')
opt.Program('foo', 'foo.c')
dbg.Program('foo', 'foo.c')
```

Then SCons generates the following error:

```
% scons -Q
scons: *** Two environments with different actions were specified for the same target: foo.o
File "~/home/my/project/SConstruct", line 6, in <module>
```

This is because the two `Program` calls have each implicitly told SCons to generate an object file named `foo.o`, one with a `CCFLAGS` value of `-O2` and one with a `CCFLAGS` value of `-g`. SCons can’t just decide that one of them should take precedence over the other, so it generates the error. To avoid this problem, we must explicitly specify that each environment compile `foo.c` to a separately-named object file using the `Object` builder, like so:

```python
opt = Environment(CCFLAGS = '-O2')
dbg = Environment(CCFLAGS = '-g')
o = opt.Object('foo-opt', 'foo.c')
opt.Program(o)
d = dbg.Object('foo-dbg', 'foo.c')
dbg.Program(d)
```

Notice that each call to the `Object` builder returns a value, an internal SCons object that represents the object file that will be built. We then use that object as input to the `Program` builder. This avoids having to specify explicitly the object file name in multiple places, and makes for a compact, readable `SConstruct` file. Our SCons output then looks like:

```
% scons -Q
cc -o foo-dbg.o -c -g foo.c
cc -o foo-dbg foo-dbg.o
cc -o foo-opt.o -c -O2 foo.c
cc -o foo-opt foo-opt.o
```
7.2.6. Making Copies of Construction Environments: the Clone Method

Sometimes you want more than one construction environment to share the same values for one or more variables. Rather than always having to repeat all of the common variables when you create each construction environment, you can use the Clone method to create a copy of a construction environment.

Like the Environment call that creates a construction environment, the Clone method takes construction variable assignments, which will override the values in the copied construction environment. For example, suppose we want to use gcc to create three versions of a program, one optimized, one debug, and one with neither. We could do this by creating a "base" construction environment that sets $CC to gcc, and then creating two copies, one which sets $CCFLAGS for optimization and the other which sets $CCFLAGS for debugging:

```python
env = Environment(CC = 'gcc')
opt = env.Clone(CCFLAGS = '-O2')
dbg = env.Clone(CCFLAGS = '-g')
env.Program('foo', 'foo.c')
o = opt.Object('foo-opt', 'foo.c')
opt.Program(o)
d = dbg.Object('foo-debug', 'foo.c')
dbg.Program(d)
```

Then our output would look like:

```bash
% scons -Q
gcc -o foo.o -c foo.c
gcc -o foo foo.o
gcc -o foo-debug.o -c -g foo.c
gcc -o foo-debug foo-debug.o
gcc -o foo-opt.o -c -O2 foo.c
gcc -o foo-opt foo-opt.o
```

7.2.7. Replacing Values: the Replace Method

You can replace existing construction variable values using the Replace method:

```python
env = Environment(CCFLAGS = '-DDEFINE1')
env.Replace(CCFLAGS = '-DDEFINE2')
env.Program('foo.c')
```
The replacing value (\(-D\text{DEFINE2}\) in the above example) completely replaces the value in the construction environment:

```bash
% scons -Q
 cc -o foo.o -c -DDEFINE2 foo.c
 cc -o foo foo.o
```

You can safely call Replace for construction variables that don’t exist in the construction environment:

```python
e = Environment()
e.Replace(NEW_VARIABLE = 'xyzzy')
print "NEW_VARIABLE =", e['NEW_VARIABLE']
```

In this case, the construction variable simply gets added to the construction environment:

```bash
% scons -Q
 NEW_VARIABLE = xyzzy
 scons: `.' is up to date.
```

Because the variables aren’t expanded until the construction environment is actually used to build the targets, and because SCons function and method calls are order-independent, the last replacement "wins" and is used to build all targets, regardless of the order in which the calls to Replace() are interspersed with calls to builder methods:

```python
 e = Environment(CCFLAGS = '\-D\text{DEFINE1}')
print "CCFLAGS =", e['CCFLAGS']
 e.Program('foo.c')
 e.Replace(CCFLAGS = '\-D\text{DEFINE2}')
print "CCFLAGS =", e['CCFLAGS']
 e.Program('bar.c')
```

The timing of when the replacement actually occurs relative to when the targets get built becomes apparent if we run scons without the \(-Q\) option:

```bash
% scons
 scons: Reading SConscript files ...
 CCFLAGS = -D\text{DEFINE1}
 CCFLAGS = -D\text{DEFINE2}
 scons: done reading SConscript files.
 scons: Building targets ...
 cc -o bar.o -c -D\text{DEFINE2} bar.c
 cc -o bar bar.o
 cc -o foo.o -c -D\text{DEFINE2} foo.c
 cc -o foo foo.o
 scons: done building targets.
```
Because the replacement occurs while the `SConscript` files are being read, the `$CCFLAGS` variable has already been set to `-DDEFINE2` by the time the `foo.o` target is built, even though the call to the `Replace` method does not occur until later in the `SConscript` file.

### 7.2.8. Setting Values Only If They’re Not Already Defined: the `SetDefault` Method

Sometimes it’s useful to be able to specify that a construction variable should be set to a value only if the construction environment does not already have that variable defined. You can do this with the `SetDefault` method, which behaves similarly to the `set_default` method of Python dictionary objects:

```python
env.SetDefault(SPECIAL_FLAG = '-extra-option')
```

This is especially useful when writing your own `Tool` modules to apply variables to construction environments.

### 7.2.9. Appending to the End of Values: the `Append` Method

You can append a value to an existing construction variable using the `Append` method:

```python
env = Environment(CCFLAGS = ['-DMY_VALUE'])
env.Append(CCFLAGS = ['-DLAST'])
env.Program('foo.c')
```

`SCons` then supplies both the `-DMY_VALUE` and `-DLAST` flags when compiling the object file:

```bash
% scons -Q
cc -o foo.o -c -DMY_VALUE -DLAST foo.c
cc -o foo foo.o
```

If the construction variable doesn’t already exist, the `Append` method will create it:

```python
env = Environment()
env.Append(NEW_VARIABLE = 'added')
print "NEW_VARIABLE =", env['NEW_VARIABLE']
```

Which yields:
$ scons -Q
NEW_VARIABLE = added
scons: '.' is up to date.

Note that the `Append` function tries to be "smart" about how the new value is appended to the old value. If both are strings, the previous and new strings are simply concatenated. Similarly, if both are lists, the lists are concatenated. If, however, one is a string and the other is a list, the string is added as a new element to the list.

### 7.2.10. Appending Unique Values: the `AppendUnique` Method

Some times it’s useful to add a new value only if the existing construction variable doesn’t already contain the value. This can be done using the `AppendUnique` method:

```python
env.AppendUnique(CCFLAGS=['-g'])
```

In the above example, the `-g` would be added only if the `$CCFLAGS` variable does not already contain a `-g` value.

### 7.2.11. Appending to the Beginning of Values: the `Prepend` Method

You can append a value to the beginning of an existing construction variable using the `Prepend` method:

```python
env = Environment(CCFLAGS = ['-DMY_VALUE'])
env.Prepend(CCFLAGS = ['-DFIRST'])
env.Program('foo.c')
```

SCons then supplies both the `-DFIRST` and `-DMY_VALUE` flags when compiling the object file:

```bash
% scons -Q
cc -o foo.o -c -DFIRST -DMY_VALUE foo.c
cc -o foo foo.o
```

If the construction variable doesn’t already exist, the `Prepend` method will create it:

```python
env = Environment()
env.Prepend(NEW_VARIABLE = 'added')
print "NEW_VARIABLE =", env['NEW_VARIABLE']
```
Which yields:

```
% scons -Q
NEW_VARIABLE = added
scons: `.' is up to date.
```

Like the `Append` function, the `Prepend` function tries to be "smart" about how the new value is appended to the old value. If both are strings, the previous and new strings are simply concatenated. Similarly, if both are lists, the lists are concatenated. If, however, one is a string and the other is a list, the string is added as a new element to the list.

### 7.2.12. Prepending Unique Values: the `PrependUnique` Method

Some times it’s useful to add a new value to the beginning of a construction variable only if the existing value doesn’t already contain the to-be-added value. This can be done using the `PrependUnique` method:

```
env.PrependUnique(CCFLAGS=['-g'])
```

In the above example, the `-g` would be added only if the `$CCFLAGS` variable does not already contain a `-g` value.

### 7.3. Controlling the Execution Environment for Issued Commands

When SCons builds a target file, it does not execute the commands with the same external environment that you used to execute SCons. Instead, it uses the dictionary stored in the `$ENV` construction variable as the external environment for executing commands.

The most important ramification of this behavior is that the `PATH` environment variable, which controls where the operating system will look for commands and utilities, is not the same as in the external environment from which you called SCons. This means that SCons will not, by default, necessarily find all of the tools that you can execute from the command line.

The default value of the `PATH` environment variable on a POSIX system is 
`/usr/local/bin:/bin:/usr/bin`. The default value of the `PATH` environment variable on a Windows system comes from the Windows registry value for the command interpreter. If you want to execute any commands--compilers, linkers, etc.--that are not in these default locations, you need to set the `PATH` value in the `$ENV` dictionary in your construction environment.
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The simplest way to do this is to initialize explicitly the value when you create the construction environment; this is one way to do that:

```python
path = ['/usr/local/bin', '/bin', '/usr/bin']
env = Environment(ENV = {'PATH' : path})
```

Assign a dictionary to the $ENV construction variable in this way completely resets the external environment so that the only variable that will be set when external commands are executed will be the `PATH` value. If you want to use the rest of the values in $ENV and only set the value of `PATH`, the most straightforward way is probably:

```python
env['ENV']['PATH'] = ['/usr/local/bin', '/bin', '/usr/bin']
```

Note that SCons does allow you to define the directories in the `PATH` in a string, separated by the pathname-separator character for your system (`:` on POSIX systems, `;` on Windows):

```python
env['ENV']['PATH'] = '/usr/local/bin:/bin:/usr/bin'
```

But doing so makes your `SCons` file less portable, (although in this case that may not be a huge concern since the directories you list are likely system-specific, anyway).

### 7.3.1. Propagating `PATH` From the External Environment

You may want to propagate the external `PATH` to the execution environment for commands. You do this by initializing the `PATH` variable with the `PATH` value from the `os.environ` dictionary, which is Python’s way of letting you get at the external environment:

```python
import os
env = Environment(ENV = {'PATH' : os.environ['PATH']})
```

Alternatively, you may find it easier to just propagate the entire external environment to the execution environment for commands. This is simpler to code than explicitly selecting the `PATH` value:

```python
import os
env = Environment(ENV = os.environ)
```

Either of these will guarantee that SCons will be able to execute any command that you can execute from the command line. The drawback is that the build can behave differently if it’s run by people with different `PATH` values in their environment—for example, if both the `/bin` and `/usr/local/bin` directories have different `cc` commands, then which one will be used to compile programs will depend on which directory is listed first in the user’s `PATH` variable.
7.3.2. Adding to PATH Values in the Execution Environment

One of the most common requirements for manipulating a variable in the execution environment is to add one or more custom directories to a search like the $PATH variable on Linux or POSIX systems, or the %PATH% variable on Windows, so that a locally-installed compiler or other utility can be found when SCons tries to execute it to update a target. SCons provides `PrependENVPath` and `AppendENVPath` functions to make adding things to execution variables convenient. You call these functions by specifying the variable to which you want the value added, and then value itself. So to add some /usr/local directories to the $PATH and $LIB variables, you might:

```python
env = Environment(ENV = os.environ)
env.PrependENVPath('PATH', '/usr/local/bin')
env.AppendENVPath('LIB', '/usr/local/lib')
```

Note that the added values are strings, and if you want to add multiple directories to a variable like $PATH, you must include the path separate character (:\ on Linux or POSIX, ; on Windows) in the string.
Chapter 8. Merging Options into the Environment: the MergeFlags Function

SCons construction environments have a MergeFlags method that merges a dictionary of values into the construction environment. MergeFlags treats each value in the dictionary as a list of options such as one might pass to a command (such as a compiler or linker). MergeFlags will not duplicate an option if it already exists in the construction environment variable.

MergeFlags tries to be intelligent about merging options. When merging options to any variable whose name ends in PATH, MergeFlags keeps the leftmost occurrence of the option, because in typical lists of directory paths, the first occurrence "wins." When merging options to any other variable name, MergeFlags keeps the rightmost occurrence of the option, because in a list of typical command-line options, the last occurrence "wins."

```python
env = Environment()
env.Append(CCFLAGS = '-option -O3 -O1')
flags = { 'CCFLAGS' : '-whatever -O3' }
env.MergeFlags(flags)
print env['CCFLAGS']
```

```
% scons -Q
['-option', '-O1', '-whatever', '-O3']
scons: '.' is up to date.
```

Note that the default value for $CCFLAGS is an internal SCons object which automatically converts the options we specified as a string into a list.

```python
env = Environment()
env.Append(CPPPATH = ['/include', '/usr/local/include', '/usr/include'])
flags = { 'CPPPATH' : ['/usr/opt/include', '/usr/local/include'] } 
env.MergeFlags(flags)
print env['CPPPATH']
```

```
% scons -Q
['/include', '/usr/local/include', '/usr/include', '/usr/opt/include']
scons: '.' is up to date.
```

Note that the default value for $CPPPATH is a normal Python list, so we must specify its values as a list in the dictionary we pass to the MergeFlags function.

If MergeFlags is passed anything other than a dictionary, it calls the ParseFlags method to convert it into a dictionary.
env = Environment()
env.Append(CCFLAGS = '-option -O3 -O1')
env.Append(CPPPATH = ['/include', '/usr/local/include', '/usr/include'])
env.MergeFlags('-whatever -I/usr/opt/include -O3 -I/usr/local/include')
print env['CCFLAGS']
print env['CPPPATH']

%%scons -Q
 ['-option', '-O1', '-whatever', '-O3']
 ['/include', '/usr/local/include', '/usr/include', '/usr/opt/include']
scons: '.' is up to date.

In the combined example above, ParseFlags has sorted the options into their corresponding variables and returned a dictionary for MergeFlags to apply to the construction variables in the specified construction environment.
Chapter 9. Separating Compile Arguments into their Variables: the ParseFlags Function

SCons has a bewildering array of construction variables for different types of options when building programs. Sometimes you may not know exactly which variable should be used for a particular option.

SCons construction environments have a ParseFlags method that takes a set of typical command-line options and distributes them into the appropriate construction variables. Historically, it was created to support the ParseConfig method, so it focuses on options used by the GNU Compiler Collection (GCC) for the C and C++ toolchains.

ParseFlags returns a dictionary containing the options distributed into their respective construction variables. Normally, this dictionary would be passed to MergeFlags to merge the options into a construction environment, but the dictionary can be edited if desired to provide additional functionality. (Note that if the flags are not going to be edited, calling MergeFlags with the options directly will avoid an additional step.)

```python
env = Environment()
d = env.ParseFlags("-I/opt/include -L/opt/lib -lfoo")
l = d.items()
l.sort()
for k, v in l:
    if v:
        print k, v
env.MergeFlags(d)
env.Program('f1.c')
```

Note that if the options are limited to generic types like those above, they will be correctly translated for other platform types:

```cmd
C:\>scons -Q
CPPPATH ["/opt/include"]
LIBPATH ["/opt/lib"]
LIBS ["foo"]
cc -o f1.o -c -I/opt/include f1.c
cc -o f1 f1.o -L/opt/lib -lfoo
```

```python
% scons -Q
CPPPATH ["/opt/include"]
LIBPATH ["/opt/lib"]
LIBS ["foo"]
cc -o f1.o -c -I/opt/include f1.c
cc -o f1 f1.o -L/opt/lib -lfoo
```

```cmd
C:\>scons -Q
CPPPATH ["/opt/include"]
LIBPATH ["/opt/lib"]
LIBS ["foo"]
c1 /Fofoo.obj /c f1.c /nologo /I\opt\include
link /nologo /OUT:f1.exe /LIBPATH:\opt\lib foo.lib f1.obj
```
Chapter 9. Separating Compile Arguments into their Variables: the \texttt{ParseFlags} Function

Since the assumption is that the flags are used for the GCC toolchain, unrecognized flags are placed in \texttt{SCCFLAGS} so they will be used for both C and C++ compiles:

```python
env = Environment()
d = env.ParseFlags("-whatever")
l = d.items()
l.sort()
for k,v in l:
    if v:
        print k, v
env.MergeFlags(d)
env.Program('f1.c')

% scons -Q
CCFLAGS -whatever
cc -o f1.o -c -whatever f1.c
cc -o f1 f1.o
```

\texttt{ParseFlags} will also accept a (recursive) list of strings as input; the list is flattened before the strings are processed:

```python
env = Environment()
d = env.ParseFlags(['-I/opt/include', ['-L/opt/lib', '-lfoo']])
l = d.items()
l.sort()
for k,v in l:
    if v:
        print k, v
env.MergeFlags(d)
env.Program('f1.c')

% scons -Q
CPPPATH ['/opt/include']
LIBPATH ['/opt/lib']
LIBS ['foo']
cc -o f1.o -c -I/opt/include f1.c
cc -o f1 f1.o -L/opt/lib -lfoo
```

If a string begins with a "!" (an exclamation mark, often called a bang), the string is passed to the shell for execution. The output of the command is then parsed:

```python
env = Environment()
d = env.ParseFlags(['"!echo -I/opt/include", "!echo -L/opt/lib", "-lfoo"'])
l = d.items()
l.sort()
for k,v in l:
    if v:
        print k, v
```

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Chapter 9. Separating Compile Arguments into their Variables: the ParseFlags Function

```python
env.MergeFlags(d)
env.Program('f1.c')

% scons -Q
CPPPATH ['/opt/include']
LIBPATH ['/opt/lib']
LIBS ['foo']
cc -o f1.o -c -I/opt/include f1.c
cc -o f1 f1.o -L/opt/lib -lfoo
```

ParseFlags is regularly updated for new options; consult the man page for details about those currently recognized.
Chapter 10. Finding Installed Library Information: the ParseConfig Function

Configuring the right options to build programs to work with libraries—especially shared libraries—that are available on POSIX systems can be very complicated. To help this situation, various utilities with names that end in `config` return the command-line options for the GNU Compiler Collection (GCC) that are needed to use these libraries; for example, the command-line options to use a library named `lib` would be found by calling a utility named `lib-config`.

A more recent convention is that these options are available from the generic `pkg-config` program, which has common framework, error handling, and the like, so that all the package creator has to do is provide the set of strings for his particular package.

SCons construction environments have a ParseConfig method that executes a `*config` utility (either `pkg-config` or a more specific utility) and configures the appropriate construction variables in the environment based on the command-line options returned by the specified command.

```python
env = Environment()
env['CPPPATH'] = ['/lib/compat']
env.ParseConfig("pkg-config x11 --cflags --libs")
print env['CPPPATH']
```

SCons will execute the specified command string, parse the resultant flags, and add the flags to the appropriate environment variables.

```
% scons -Q
['/lib/compat', '/usr/X11/include']
scons: `.,' is up to date.
```

In the example above, SCons has added the include directory to `CPPPATH`. (Depending upon what other flags are emitted by the `pkg-config` command, other variables may have been extended as well.)

Note that the options are merged with existing options using the `MergeFlags` method, so that each option only occurs once in the construction variable:

```python
env = Environment()
env.ParseConfig("pkg-config x11 --cflags --libs")
env.ParseConfig("pkg-config x11 --cflags --libs")
print env['CPPPATH']
```

```
% scons -Q
['/usr/X11/include']
```
Chapter 10. Finding Installed Library Information: the ParseConfig Function

scons: `.' is up to date.
Chapter 11. Controlling Build Output

A key aspect of creating a usable build configuration is providing good output from the build so its users can readily understand what the build is doing and get information about how to control the build. SCons provides several ways of controlling output from the build configuration to help make the build more useful and understandable.

11.1. Providing Build Help: the `Help` Function

It's often very useful to be able to give users some help that describes the specific targets, build options, etc., that can be used for your build. SCons provides the `Help` function to allow you to specify this help text:

```python
Help(""
Type: 'scons program' to build the production program,
    'scons debug' to build the debug version.
"")
```

(Note the above use of the Python triple-quote syntax, which comes in very handy for specifying multi-line strings like help text.)

When the `SConstruct` or `SConscript` files contain such a call to the `Help` function, the specified help text will be displayed in response to the SCons `--help` option:

```
% scons --help
scons: Reading SConscript files ...
scons: done reading SConscript files.

Type: 'scons program' to build the production program,
    'scons debug' to build the debug version.

Use scons --help for help about command-line options.
```

The `SConscript` files may contain multiple calls to the `Help` function, in which case the specified text(s) will be concatenated when displayed. This allows you to split up the help text across multiple `SConscript` files. In this situation, the order in which the `SConscript` files are called will determine the order in which the `Help` functions are called, which will determine the order in which the various bits of text will get concatenated.

Another use would be to make the help text conditional on some variable. For example, suppose you only want to display a line about building a Windows-only version of a program when actually run on Windows. The following `SConstruct` file:
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```
env = Environment()
Help("\nType: 'scons program' to build the production program.\n")

if env['PLATFORM'] == 'win32':
    Help("\nType: 'scons windebug' to build the Windows debug version.\n")
```

Will display the complete help text on Windows:

```
C:\>scons -h
scons: Reading SConscript files ...
scons: done reading SConscript files.

Type: 'scons program' to build the production program.

Type: 'scons windebug' to build the Windows debug version.

Use scons -H for help about command-line options.
```

But only show the relevant option on a Linux or UNIX system:

```
% scons -h
scons: Reading SConscript files ...
scons: done reading SConscript files.

Type: 'scons program' to build the production program.

Use scons -H for help about command-line options.
```

If there is no Help text in the SConstruct or SConscript files, SCons will revert to displaying its standard list that describes the SCons command-line options. This list is also always displayed whenever the -H option is used.

11.2. Controlling How SCons Prints Build Commands: the $*COMSTR Variables

Sometimes the commands executed to compile object files or link programs (or build other targets) can get very long, long enough to make it difficult for users to distinguish error messages or other important build output from the commands themselves. All of the default $*COM variables that specify the command lines used to build various types of target files have a corresponding $*COMSTR variable that can be set to an alternative string that will be displayed when the target is built.
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For example, suppose you want to have SCons display a "Compiling" message whenever it’s compiling an object file, and a "Linking" when it’s linking an executable. You could write a SConstruct file that looks like:

```python
env = Environment(CCCOMSTR = "Compiling $TARGET",
                  LINKCOMSTR = "Linking $TARGET")
env.Program('foo.c')
```

Which would then yield the output:

```bash
% scons -Q
Compiling foo.o
Linking foo
```

SCons performs complete variable substitution on $*COMSTR variables, so they have access to all of the standard variables like $TARGET $SOURCES, etc., as well as any construction variables that happen to be configured in the construction environment used to build a specific target.

Of course, sometimes it’s still important to be able to see the exact command that SCons will execute to build a target. For example, you may simply need to verify that SCons is configured to supply the right options to the compiler, or a developer may want to cut-and-paste a comiloe command to add a few options for a custom test.

One common way to give users control over whether or not SCons should print the actual command line or a short, configured summary is to add support for a VERBOSE command-line variable to your SConstruct file. A simple configuration for this might look like:

```python
env = Environment()
if ARGUMENTS.get('VERBOSE') != "1":
    env['CCCOMSTR'] = "Compiling $TARGET"
    env['LINKCOMSTR'] = "Linking $TARGET"
env.Program('foo.c')
```

By only setting the appropriate $*COMSTR variables if the user specifies VERBOSE=1 on the command line, the user has control over how SCons displays these particular command lines:

```bash
% scons -Q
Compiling foo.o
Linking foo
% scons -Q -c
Removed foo.o
Removed foo
% scons -Q VERBOSE=1
cc -o foo.o -c foo.c
cc -o foo foo.o
```
11.3. Providing Build Progress Output: the Progress Function

Another aspect of providing good build output is to give the user feedback about what SCons is doing even when nothing is being built at the moment. This can be especially true for large builds when most of the targets are already up-to-date. Because SCons can take a long time making absolutely sure that every target is, in fact, up-to-date with respect to a lot of dependency files, it can be easy for users to mistakenly conclude that SCons is hung or that there is some other problem with the build.

One way to deal with this perception is to configure SCons to print something to let the user know what it’s "thinking about." The Progress function allows you to specify a string that will be printed for every file that SCons is "considering" while it is traversing the dependency graph to decide what targets are or are not up-to-date.

```
Progress('Evaluating $TARGET\n')
Program('f1.c')
Program('f2.c')
```

Note that the Progress function does not arrange for a newline to be printed automatically at the end of the string (as does the Python print statement), and we must specify the \n that we want printed at the end of the configured string. This configuration, then, will have SCons print that it is Evaluating each file that it encounters in turn as it traverses the dependency graph:

```
% scons -Q
Evaluating SConstruct
Evaluating f1.c
Evaluating f1.o
cc -o f1.o -c f1.c
Evaluating f1
cc -o f1 f1.o
Evaluating f2.c
Evaluating f2.o
cc -o f2.o -c f2.c
Evaluating f2
cc -o f2 f2.o
Evaluating .
```

Of course, normally you don’t want to add all of these additional lines to your build output, as that can make it difficult for the user to find errors or other important messages. A more useful way to display this progress might be to have the file names printed directly to the user’s screen, not to the same standard
output stream where build output is printed, and to use a carriage return character (\r) so that each file name gets re-printed on the same line. Such a configuration would look like:

```python
Progress('$TARGET\r',
    file=open('/dev/tty', 'w'),
    overwrite=True)
Program('f1.c')
Program('f2.c')
```

Note that we also specified the overwrite=True argument to the Progress function, which causes SCons to "wipe out" the previous string with space characters before printing the next Progress string. Without the overwrite=True argument, a shorter file name would not overwrite all of the characters in a longer file name that precedes it, making it difficult to tell what the actual file name is on the output. Also note that we opened up the /dev/tty file for direct access (on POSIX) to the user’s screen. On Windows, the equivalent would be to open the con: file name.

Also, it’s important to know that although you can use $TARGET to substitute the name of the node in the string, the Progress function does not perform general variable substitution (because there’s not necessarily a construction environment involved in evaluating a node like a source file, for example).

You can also specify a list of strings to the Progress function, in which case SCons will display each string in turn. This can be used to implement a "spinner" by having SCons cycle through a sequence of strings:

```python
Progress(['-', '\\', ' |\', '\r', '/\r'], interval=5)
Program('f1.c')
Program('f2.c')
```

Note that here we have also used the interval= keyword argument to have SCons only print a new "spinner" string once every five evaluated nodes. Using an interval= count, even with strings that use $TARGET like our examples above, can be a good way to lessen the work that SCons expends printing Progress strings, while still giving the user feedback that indicates SCons is still working on evaluating the build.

Lastly, you can have direct control over how to print each evaluated node by passing a Python function (or other Python callable) to the Progress function. Your function will be called for each evaluated node, allowing you to implement more sophisticated logic like adding a counter:

```python
screen = open('/dev/tty', 'w')
count = 0
def progress_function(node)
    count += 1
    screen.write('Node %4d: %s\r % (count, node))

Progress(progress_function)
```
Of course, if you choose, you could completely ignore the `node` argument to the function, and just print a count, or anything else you wish.

(Note that there’s an obvious follow-on question here: how would you find the total number of nodes that \textit{will be} evaluated so you can tell the user how close the build is to finishing? Unfortunately, in the general case, there isn’t a good way to do that, short of having SCons evaluate its dependency graph twice, first to count the total and the second time to actually build the targets. This would be necessary because you can’t know in advance which target(s) the user actually requested to be built. The entire build may consist of thousands of Nodes, for example, but maybe the user specifically requested that only a single object file be built.)

### 11.4. Printing Detailed Build Status: the \texttt{GetBuildFailures} Function

SCons, like most build tools, returns zero status to the shell on success and nonzero status on failure. Sometimes it’s useful to give more information about the build status at the end of the run, for instance to print an informative message, send an email, or page the poor slob who broke the build.

SCons provides a \texttt{GetBuildFailures} method that you can use in a python `atexit` function to get a list of objects describing the actions that failed while attempting to build targets. There can be more than one if you’re using `-j`. Here’s a simple example:

```python
import atexit

def print_build_failures():
    from SCons.Script import GetBuildFailures
    for bf in GetBuildFailures():
        print "%s failed: %s" % (bf.node, bf.errstr)
atexit.register(print_build_failures)
```

The `atexit.register` call registers `print_build_failures` as an `atexit` callback, to be called before SCons exits. When that function is called, it calls `GetBuildFailures` to fetch the list of failed objects. See the man page for the detailed contents of the returned objects; some of the more useful attributes are `.node`, `.errstr`, `.filename`, and `.command`. The `.filename` is not necessarily the same file as the `.node`; the `.node` is the target that was being built when the error occurred, while the `.filename`is the file or dir that actually caused the error. Note: only call `GetBuildFailures` at the end of the build; calling it at any other time is undefined.

Here is a more complete example showing how to turn each element of `GetBuildFailures` into a string:

```python
# Make the build fail if we pass fail=1 on the command line
if ARGUMENTS.get(‘fail’, 0):
```
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Command(‘target’, ‘source’, [’/bin/false’])

def bf_to_str(bf):
    """Convert an element of GetBuildFailures() to a string
    in a useful way."""
    import SCons.Errors
    if bf is None: # unknown targets product None in list
        return ’(unknown tgt)’
    elif isinstance(bf, SCons.Errors.StopError):
        return str(bf)
    elif bf.node:
        return str(bf.node) + ’: ’ + bf.errstr
    elif bf.filename:
        return bf.filename + ’: ’ + bf.errstr
    return ’unknown failure: ’ + bf.errstr

import atexit

def build_status():
    """Convert the build status to a 2-tuple, (status, msg)."""
    from SCons.Script import GetBuildFailures
    bf = GetBuildFailures()
    if bf:
        # bf is normally a list of build failures; if an element is None,
        # it’s because of a target that scons doesn’t know anything about.
        status = ’failed’
        failures_message = ”
        join([”Failed building %s” % bf_to_str(x)
                              for x in bf if x is not None])
    else:
        # if bf is None, the build completed successfully.
        status = ’ok’
        failures_message = ”
    return (status, failures_message)

def display_build_status():
    """Display the build status. Called by atexit.
    Here you could do all kinds of complicated things."""
    status, failures_message = build_status()
    if status == ’failed’:
        print ”FAILED!!!!!” # could display alert, ring bell, etc.
    elif status == ’ok’:
        print ”Build succeeded.”
    print failures_message

atexit.register(display_build_status)

When this runs, you’ll see the appropriate output:

```
% scons -Q
scons: `.’ is up to date.
Build succeeded.
% scons -Q fail=1
```
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scons: *** Source ‘source’ not found, needed by target ‘target’. Stop.
FAILED!!!!
Failed building Source ‘source’ not found, needed by target ‘target’.
Chapter 12. Controlling a Build From the Command Line

SCons provides a number of ways for the writer of the SConscript files to give the users who will run SCons a great deal of control over the build execution. The arguments that the user can specify on the command line are broken down into three types:

Options

Command-line options always begin with one or two – (hyphen) characters. SCons provides ways for you to examine and set options values from within your SConscript files, as well as the ability to define your own custom options. See Section 12.1, below.

Variables

Any command-line argument containing an = (equal sign) is considered a variable setting with the form variable=value SCons provides direct access to all of the command-line variable settings, the ability to apply command-line variable settings to construction environments, and functions for configuring specific types of variables (Boolean values, path names, etc.) with automatic validation of the user’s specified values. See Section 12.2, below.

Targets

Any command-line argument that is not an option or a variable setting (does not begin with a hyphen and does not contain an equal sign) is considered a target that the user (presumably) wants SCons to build. A list of Node objects representing the target or targets to build. SCons provides access to the list of specified targets, as well as ways to set the default list of targets from within the SConscript files. See Section 12.3, below.

12.1. Command-Line Options

SCons has many command-line options that control its behavior. A SCons command-line option always begins with one or two – (hyphen) characters.

12.1.1. Not Having to Specify Command-Line Options Each Time: the SCONSFLAGS Environment Variable

Users may find themselves supplying the same command-line options every time they run SCons. For example, you might find it saves time to specify a value of -j 2 to have SCons run up to two build commands in parallel. To avoid having to type -j 2 by hand every time, you can set the external environment variable SCONSFLAGS to a string containing command-line options that you want SCons to use.
If, for example, you’re using a POSIX shell that’s compatible with the Bourne shell, and you always want SCons to use the `-Q` option, you can set the `SCONSFLAGS` environment as follows:

```
% scons
scons: Reading SConscript files ...
scons: done reading SConscript files.
scons: Building targets ...
    ... [build output] ...
scons: done building targets.
% export SCONSFLAGS="-Q"
% scons
    ... [build output] ...
```

Users of csh-style shells on POSIX systems can set the `SCONSFLAGS` environment as follows:

```
$ setenv SCONSFLAGS "-Q"
```

Windows users may typically want to set the `SCONSFLAGS` in the appropriate tab of the System Properties window.

### 12.1.2. Getting Values Set by Command-Line Options: the `GetOption` Function

SCons provides the `GetOption` function to get the values set by the various command-line options. One common use of this is to check whether or not the `-h` or `--help` option has been specified. Normally, SCons does not print its help text until after it has read all of the `SConscript` files, because it’s possible that help text has been added by some subsidiary `SConscript` file deep in the source tree hierarchy. Of course, reading all of the `SConscript` files takes extra time.

If you know that your configuration does not define any additional help text in subsidiary `SConscript` files, you can speed up the command-line help available to users by using the `GetOption` function to load the subsidiary `SConscript` files only if the the user has *not* specified the `-h` or `--help` option, like so:

```
In general, the string that you pass to the `GetOption` function to fetch the value of a command-line option setting is the same as the "most common" long option name (beginning with two hyphen characters), although there are some exceptions. The list of SCons command-line options and the `GetOption` strings for fetching them, are available in the Section 12.1.4 section, below.
12.1.3. Setting Values of Command-Line Options: the SetOption Function

You can also set the values of SCons command-line options from within the SConscript files by using the SetOption function. The strings that you use to set the values of SCons command-line options are available in the Section 12.1.4 section, below.

One use of the SetOption function is to specify a value for the \texttt{-j} or \texttt{--jobs} option, so that users get the improved performance of a parallel build without having to specify the option by hand. A complicating factor is that a good value for the \texttt{-j} option is somewhat system-dependent. One rough guideline is that the more processors your system has, the higher you want to set the \texttt{-j} value, in order to take advantage of the number of CPUs.

For example, suppose the administrators of your development systems have standardized on setting a \texttt{NUM\_CPU} environment variable to the number of processors on each system. A little bit of Python code to access the environment variable and the SetOption function provide the right level of flexibility:

```python
import os
num_cpu = int(os.environ.get('NUM\_CPU', 2))
SetOption('num\_jobs', num_cpu)
print "running with -j", GetOption('num\_jobs')
```

The above snippet of code sets the value of the \texttt{--jobs} option to the value specified in the \texttt{NUM\_CPU} environment variable. (This is one of the exception cases where the string is spelled differently from the from command-line option. The string for fetching or setting the \texttt{--jobs} value is \texttt{num\_jobs} for historical reasons.) The code in this example prints the \texttt{num\_jobs} value for illustrative purposes. It uses a default value of 2 to provide some minimal parallelism even on single-processor systems:

```
% scons -Q
running with -j 2
scons: '.' is up to date.
```

But if the \texttt{NUM\_CPU} environment variable is set, then we use that for the default number of jobs:

```
% export NUM\_CPU="4"
% scons -Q
running with -j 4
scons: '.' is up to date.
```

But any explicit \texttt{-j} or \texttt{--jobs} value the user specifies an the command line is used first, regardless of whether or not the \texttt{NUM\_CPU} environment variable is set:

```
% scons -Q -j 7
running with -j 7
```
12.1.4. Strings for Getting or Setting Values of SCons Command-Line Options

The strings that you can pass to the GetOption and SetOption functions usually correspond to the first long-form option name (beginning with two hyphen characters: --), after replacing any remaining hyphen characters with underscores.

The full list of strings and the variables they correspond to is as follows:

<table>
<thead>
<tr>
<th>String for GetOption and SetOption</th>
<th>Command-Line Option(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>cache_debug</td>
<td>--cache-debug</td>
</tr>
<tr>
<td>cache_disable</td>
<td>--cache-disable</td>
</tr>
<tr>
<td>cache_force</td>
<td>--cache-force</td>
</tr>
<tr>
<td>cache_show</td>
<td>--cache-show</td>
</tr>
<tr>
<td>clean</td>
<td>-c,--clean,--remove</td>
</tr>
<tr>
<td>config</td>
<td>--config</td>
</tr>
<tr>
<td>directory</td>
<td>-C,--directory</td>
</tr>
<tr>
<td>diskcheck</td>
<td>--diskcheck</td>
</tr>
<tr>
<td>duplicate</td>
<td>--duplicate</td>
</tr>
<tr>
<td>file</td>
<td>-f,--file,--makefile,--sconstruct</td>
</tr>
<tr>
<td>help</td>
<td>-h,--help</td>
</tr>
<tr>
<td>ignore_errors</td>
<td>--ignore-errors</td>
</tr>
<tr>
<td>implicit_cache</td>
<td>--implicit-cache</td>
</tr>
<tr>
<td>implicit_deps_changed</td>
<td>--implicit-deps-changed</td>
</tr>
<tr>
<td>implicit_deps_unchanged</td>
<td>--implicit-deps-unchanged</td>
</tr>
<tr>
<td>interactive</td>
<td>--interact,--interactive</td>
</tr>
<tr>
<td>keep_going</td>
<td>-k,--keep-going</td>
</tr>
<tr>
<td>max_drift</td>
<td>--max-drift</td>
</tr>
<tr>
<td>no_exec</td>
<td>-n,--no-exec,--just-print,--dry-run,--recon</td>
</tr>
<tr>
<td>no_site_dir</td>
<td>--no-site-dir</td>
</tr>
<tr>
<td>num_jobs</td>
<td>-j,--jobs</td>
</tr>
<tr>
<td>profile_file</td>
<td>--profile</td>
</tr>
</tbody>
</table>
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### 12.1.5. Adding Custom Command-Line Options: the `AddOption` Function

SCons also allows you to define your own command-line options with the `AddOption` function. The `AddOption` function takes the same arguments as the `optparse.add_option` function from the standard Python library. Once you have added a custom command-line option with the `AddOption` function, the value of the option (if any) is immediately available using the standard `GetOption` function. (The value can also be set using `SetOption`, although that’s not very useful in practice because a default value can be specified in directly in the `AddOption` call.)

One useful example of using this functionality is to provide a `--prefix` for users:

```python
AddOption('--prefix',
    dest='prefix',
    type='string',
    nargs=1,
    action='store',
    metavar='DIR',
    help='installation prefix')

env = Environment(PREFIX = GetOption('prefix'))

installed_foo = env.Install('$PREFIX/usr/bin', 'foo.in')
Default(installed_foo)
```

The above code uses the `GetOption` function to set the `$PREFIX` construction variable to any value that the user specifies with a command-line option of `--prefix`. Because `$PREFIX` will expand to a null string if it’s not initialized, running SCons without the option of `--prefix` will install the file in the `/usr/bin/` directory:

```
% scons -Q -n
Install file: "foo.in" as "/usr/bin/foo.in"
```
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But specifying `--prefix=/tmp/install` on the command line causes the file to be installed in the `/tmp/install/usr/bin/` directory:

```
% scons -Q -n --prefix=/tmp/install
Install file: "foo.in" as "/tmp/install/usr/bin/foo.in"
```

### 12.2. Command-Line `variable=value` Build Variables

You may want to control various aspects of your build by allowing the user to specify `variable=value` values on the command line. For example, suppose you want users to be able to build a debug version of a program by running SCons as follows:

```
% scons -Q debug=1
```

SCons provides an `ARGUMENTS` dictionary that stores all of the `variable=value` assignments from the command line. This allows you to modify aspects of your build in response to specifications on the command line. (Note that unless you want to require that users *always* specify a variable, you probably want to use the Python `ARGUMENTS.get()` function, which allows you to specify a default value to be used if there is no specification on the command line.)

The following code sets the `$CCFLAGS` construction variable in response to the `debug` flag being set in the `ARGUMENTS` dictionary:

```python
env = Environment()
duggage = ARGUMENTS.get('debug', 0)
if int(debug):
    env.Append(CCFLAGS = '-g')
env.Program('prog.c')
```

This results in the `-g` compiler option being used when `debug=1` is used on the command line:

```
% scons -Q debug=0
cc -o prog.o -c prog.c
cc -o prog prog.o
% scons -Q debug=0
scons: '.' is up to date.
% scons -Q debug=1
cc -o prog.o -c -g prog.c
cc -o prog prog.o
% scons -Q debug=1
scons: '.' is up to date.
```
Notice that SCons keeps track of the last values used to build the object files, and as a result correctly rebuilds the object and executable files only when the value of the `debug` argument has changed.

The `ARGUMENTS` dictionary has two minor drawbacks. First, because it is a dictionary, it can only store one value for each specified keyword, and thus only "remembers" the last setting for each keyword on the command line. This makes the `ARGUMENTS` dictionary inappropriate if users should be able to specify multiple values on the command line for a given keyword. Second, it does not preserve the order in which the variable settings were specified, which is a problem if you want the configuration to behave differently in response to the order in which the build variable settings were specified on the command line.

To accommodate these requirements, SCons provides an `ARGLIST` variable that gives you direct access to variable=value settings on the command line, in the exact order they were specified, and without removing any duplicate settings. Each element in the `ARGLIST` variable is itself a two-element list containing the keyword and the value of the setting, and you must loop through, or otherwise select from, the elements of `ARGLIST` to process the specific settings you want in whatever way is appropriate for your configuration. For example, the following code to let the user add to the `CPPDEFINES` construction variable by specifying multiple `define=` settings on the command line:

```python
cppdefines = []
for key, value in ARGLIST:
    if key == 'define':
        cppdefines.append(value)
env = Environment(CPPDEFINES = cppdefines)
env.Object('prog.c')
```

Yields the following output:

```
% scons -Q define=FOO
cc prog.o -c -DFOO prog.c
% scons -Q define=FOO define=BAR
cc prog.o -c -DFOO -DBAR prog.c
```

Note that the `ARGLIST` and `ARGUMENTS` variables do not interfere with each other, but merely provide slightly different views into how the user specified variable=value settings on the command line. You can use both variables in the same SCons configuration. In general, the `ARGUMENTS` dictionary is more convenient to use, (since you can just fetch variable settings through a dictionary access), and the `ARGLIST` list is more flexible (since you can examine the specific order in which the user’s command-line variable settings).

### 12.2.1. Controlling Command-Line Build Variables

Being able to use a command-line build variable like `debug=1` is handy, but it can be a chore to write specific Python code to recognize each such variable, check for errors and provide appropriate messages,
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and apply the values to a construction variable. To help with this, SCons supports a class to define such build variables easily, and a mechanism to apply the build variables to a construction environment. This allows you to control how the build variables affect construction environments.

For example, suppose that you want users to set a RELEASE construction variable on the command line whenever the time comes to build a program for release, and that the value of this variable should be added to the command line with the appropriate -D option (or other command line option) to pass the value to the C compiler. Here’s how you might do that by setting the appropriate value in a dictionary for the $CPPDEFINES construction variable:

```python
vars = Variables()
vars.Add('RELEASE', 'Set to 1 to build for release', 0)
env = Environment(variables = vars,
                  CPPDEFINES={'RELEASE_BUILD' : '${RELEASE}'}
)
env.Program(['foo.c', 'bar.c'])
```

This SConstruct file first creates a Variables object (the vars = Variables() call), and then uses the object’s Add method to indicate that the RELEASE variable can be set on the command line, and that its default value will be 0 (the third argument to the Add method). The second argument is a line of help text; we’ll learn how to use it in the next section.

We then pass the created Variables object as a variables keyword argument to the Environment call used to create the construction environment. This then allows a user to set the RELEASE build variable on the command line and have the variable show up in the command line used to build each object from a C source file:

```
% scons -Q RELEASE=1
cc -o bar.o -c -DRELEASE_BUILD=1 bar.c
cc -o foo.o -c -DRELEASE_BUILD=1 foo.c
cc -o foo foo.o bar.o
```

NOTE: Before SCons release 0.98.1, these build variables were known as "command-line build options." The class was actually named the Options class, and in the sections below, the various functions were named BoolOption, EnumOption, ListOption, PathOption, PackageOption and AddOptions. These older names still work, and you may encounter them in older SConscript files, but their use is discouraged and will be officially deprecated some day.

12.2.2. Providing Help for Command-Line Build Variables

To make command-line build variables most useful, you ideally want to provide some help text that will describe the available variables when the user runs scons -h. You could write this text by hand, but SCons provides an easier way. Variables objects support a GenerateHelpText method that will, as
its name suggests, generate text that describes the various variables that have been added to it. You then
pass the output from this method to the Help function:

```python
vars = Variables('custom.py')
vars.Add('RELEASE', 'Set to 1 to build for release', 0)
env = Environment(variables = vars)
Help(vars.GenerateHelpText(env))
```

SCons will now display some useful text when the \(-h\) option is used:

```
% scons -Q -h

RELEASE: Set to 1 to build for release
  default: 0
  actual: 0

Use scons -H for help about command-line options.
```

Notice that the help output shows the default value, and the current actual value of the build variable.

### 12.2.3. Reading Build Variables From a File

Giving the user a way to specify the value of a build variable on the command line is useful, but can still
be tedious if users must specify the variable every time they run SCons. We can let users provide
customized build variable settings in a local file by providing a file name when we create the Variables
object:

```python
vars = Variables('custom.py')
vars.Add('RELEASE', 'Set to 1 to build for release', 0)
env = Environment(variables = vars,
                     CPPDEFINES={'RELEASE_BUILD' : '${RELEASE}'}
                  )
env.Program(['foo.c', 'bar.c'])
Help(vars.GenerateHelpText(env))
```

This then allows the user to control the RELEASE variable by setting it in the custom.py file:

```
RELEASE = 1
```

Note that this file is actually executed like a Python script. Now when we run SCons:

```
% scons -Q
cc -o bar.o -c -DRELEASE_BUILD=1 bar.c
cc -o foo.o -c -DRELEASE_BUILD=1 foo.c
cc -o foo foo.o bar.o
```
And if we change the contents of custom.py to:

```python
RELEASE = 0
```

The object files are rebuilt appropriately with the new variable:

```bash
% scons -Q
cc -o bar.o -c -DRELEASE_BUILD=0 bar.c
cc -o foo.o -c -DRELEASE_BUILD=0 foo.c
cc -o foo foo.o bar.o
```

12.2.4. Pre-Defined Build Variable Functions

SCons provides a number of functions that provide ready-made behaviors for various types of command-line build variables.

12.2.4.1. True/False Values: the `BoolVariable` Build Variable Function

It’s often handy to be able to specify a variable that controls a simple Boolean variable with a `true` or `false` value. It would be even more handy to accommodate users who have different preferences for how to represent `true` or `false` values. The `BoolVariable` function makes it easy to accommodate these common representations of `true` or `false`.

The `BoolVariable` function takes three arguments: the name of the build variable, the default value of the build variable, and the help string for the variable. It then returns appropriate information for passing to the `Add` method of a `Variables` object, like so:

```python
vars = Variables('custom.py')
vars.Add(BoolVariable('RELEASE', 'Set to build for release', 0))
env = Environment(variables = vars,
                   CPPDEFINES={'RELEASE_BUILD' : '${RELEASE}'})
env.Program('foo.c')
```

With this build variable, the `RELEASE` variable can now be enabled by setting it to the value `yes` or `t`:

```bash
% scons -Q RELEASE=yes foo.o
cc -o foo.o -c -DRELEASE_BUILD=True foo.c
```

```bash
% scons -Q RELEASE=t foo.o
```
Other values that equate to `true` include `y`, `1`, `on` and `all`.

Conversely, `RELEASE` may now be given a `false` value by setting it to `no` or `f`:

```
% scons -Q RELEASE=no foo.o
cc -o foo.o -c -DRELEASE_BUILD=False foo.c

% scons -Q RELEASE=f foo.o
cc -o foo.o -c -DRELEASE_BUILD=False foo.c
```

Other values that equate to `false` include `n`, `0`, `off` and `none`.

Lastly, if a user tries to specify any other value, SCons supplies an appropriate error message:

```
% scons -Q RELEASE=bad_value foo.o
scons: *** Error converting option: RELEASE
Invalid value for boolean option: bad_value
File "~/my/project/SConstruct", line 4, in <module>
```

### 12.2.4.2. Single Value From a List: the `EnumVariable` Build Variable Function

Suppose that we want a user to be able to set a `COLOR` variable that selects a background color to be displayed by an application, but that we want to restrict the choices to a specific set of allowed colors. This can be set up quite easily using the `EnumVariable`, which takes a list of `allowed_values` in addition to the variable name, default value, and help text arguments:

```python
vars = Variables('custom.py')
vars.Add(EnumVariable('COLOR', 'Set background color', 'red',
                     allowed_values=('red', 'green', 'blue')))
env = Environment(variables = vars,
                 CPPDEFINES={'COLOR' : '"${COLOR}"'})
env.Program('foo.c')
```

The user can now explicitly set the `COLOR` build variable to any of the specified allowed values:

```
% scons -Q COLOR=red foo.o
cc -o foo.o -c -DCOLOR="red" foo.c
```
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```bash
% scons -Q COLOR=blue foo.o
cc -o foo.o -c -DCOLOR="blue" foo.c
% scons -Q COLOR=green foo.o
cc -o foo.o -c -DCOLOR="green" foo.c
```

But, almost more importantly, an attempt to set `COLOR` to a value that’s not in the list generates an error message:

```bash
% scons -Q COLOR=magenta foo.o
scons: *** Invalid value for option COLOR: magenta
File "/home/my/project/SConstruct", line 5, in <module>
```

The `EnumVariable` function also supports a way to map alternate names to allowed values. Suppose, for example, that we want to allow the user to use the word `navy` as a synonym for `blue`. We do this by adding a `map` dictionary that will map its key values to the desired legal value:

```python
vars = Variables('custom.py')
vars.Add(EnumVariable('COLOR', 'Set background color', 'red',
    allowed_values=('red', 'green', 'blue'),
    map={'navy': 'blue'}))
env = Environment(variables=vars,
    CPPDEFINES={'COLOR' : '$(COLOR)'})
env.Program('foo.c')
```

As desired, the user can then use `navy` on the command line, and SCons will translate it into `blue` when it comes time to use the `COLOR` variable to build a target:

```bash
% scons -Q COLOR=navy foo.o
cc -o foo.o -c -DCOLOR="blue" foo.c
```

By default, when using the `EnumVariable` function, arguments that differ from the legal values only in case are treated as illegal values:

```bash
% scons -Q COLOR=Red foo.o
scons: *** Invalid value for option COLOR: Red
File "/home/my/project/SConstruct", line 5, in <module>
% scons -Q COLOR=BLUE foo.o
scons: *** Invalid value for option COLOR: BLUE
File "/home/my/project/SConstruct", line 5, in <module>
% scons -Q COLOR=nAvY foo.o
scons: *** Invalid value for option COLOR: nAvY
File "/home/my/project/SConstruct", line 5, in <module>
```
The `EnumVariable` function can take an additional `ignorecase` keyword argument that, when set to 1, tells SCons to allow case differences when the values are specified:

```python
vars = Variables('custom.py')
vars.Add(EnvVariable('COLOR', 'Set background color', 'red',
    allowed_values=('red', 'green', 'blue'),
    map={'navy': 'blue'},
    ignorecase=1))
env = Environment(variables=vars,
    CPPDEFINES={'COLOR': '"${COLOR}"'})
env.Program('foo.c')
```

Which yields the output:

```
% scons -Q COLOR=Red foo.o
cc -o foo.o -c -DCOLOR="Red" foo.c
% scons -Q COLOR=BLUE foo.o
cc -o foo.o -c -DCOLOR="BLUE" foo.c
% scons -Q COLOR=nAvY foo.o
cc -o foo.o -c -DCOLOR="blue" foo.c
% scons -Q COLOR=green foo.o
cc -o foo.o -c -DCOLOR="green" foo.c
```

Notice that an `ignorecase` value of 1 preserves the case-spelling that the user supplied. If you want SCons to translate the names into lower-case, regardless of the case used by the user, specify an `ignorecase` value of 2:

```python
vars = Variables('custom.py')
vars.Add(EnvVariable('COLOR', 'Set background color', 'red',
    allowed_values=('red', 'green', 'blue'),
    map={'navy': 'blue'},
    ignorecase=2))
env = Environment(variables=vars,
    CPPDEFINES={'COLOR': '"${COLOR}"'})
env.Program('foo.c')
```

Now SCons will use values of `red`, `green` or `blue` regardless of how the user spells those values on the command line:

```
% scons -Q COLOR=Red foo.o
cc -o foo.o -c -DCOLOR="red" foo.c
% scons -Q COLOR=nAvY foo.o
cc -o foo.o -c -DCOLOR="blue" foo.c
% scons -Q COLOR=GREEN foo.o
cc -o foo.o -c -DCOLOR="green" foo.c
```
12.2.4.3. Multiple Values From a List: the \texttt{ListVariable} Build Variable Function

Another way in which you might want to allow users to control a build variable is to specify a list of one or more legal values. SCons supports this through the \texttt{ListVariable} function. If, for example, we want a user to be able to set a \texttt{COLORS} variable to one or more of the legal list of values:

```python
vars = Variables('custom.py')
vars.Add(ListVariable('COLORS', 'List of colors', 0,
    ['red', 'green', 'blue']))
env = Environment(variables = vars,
    CPPDEFINES={'COLORS' : '$(COLORS)'}
)
env.Program('foo.c')
```

A user can now specify a comma-separated list of legal values, which will get translated into a space-separated list for passing to the any build commands:

```
% scons -Q COLORS=red,blue foo.o
cc -o foo.o -c -DCOLORS="red blue" foo.c
% scons -Q COLORS=blue,green,red foo.o
cc -o foo.o -c -DCOLORS="blue green red" foo.c
```

In addition, the \texttt{ListVariable} function allows the user to specify explicit keywords of \texttt{all} or \texttt{none} to select all of the legal values, or none of them, respectively:

```
% scons -Q COLORS=all foo.o
cc -o foo.o -c -DCOLORS="red green blue" foo.c
% scons -Q COLORS=none foo.o
cc -o foo.o -c -DCOLORS="" foo.c
```

And, of course, an illegal value still generates an error message:

```
% scons -Q COLORS=magenta foo.o
scons: *** Error converting option: COLORS
Invalid value(s) for option: magenta
File "~/home/my/project/SConstruct", line 5, in <module>
```
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12.2.4.4. Path Names: the PathVariable Build Variable Function

SCons supports a PathVariable function to make it easy to create a build variable to control an expected path name. If, for example, you need to define a variable in the preprocessor that controls the location of a configuration file:

```python
vars = Variables('custom.py')
vars.Add(PathVariable('CONFIG',
    'Path to configuration file',
    '/etc/my_config'))
env = Environment(variables = vars,
    CPPDEFINES={'CONFIG_FILE' : '"$CONFIG"'})
env.Program('foo.c')
```

This then allows the user to override the CONFIG build variable on the command line as necessary:

```
% scons -Q foo.o
cc -o foo.o -c -DCONFIG_FILE="/etc/my_config" foo.c
% scons -Q CONFIG=/usr/local/etc/other_config foo.o
scons: 'foo.o' is up to date.
```

By default, PathVariable checks to make sure that the specified path exists and generates an error if it doesn’t:

```
% scons -Q CONFIG="/does/not/exist" foo.o
scons: *** Path for option CONFIG does not exist: /does/not/exist
File "/home/my/project/SConstruct", line 6, in <module>
```

PathVariable provides a number of methods that you can use to change this behavior. If you want to ensure that any specified paths are, in fact, files and not directories, use the PathVariable.PathIsFile method:

```python
vars = Variables('custom.py')
vars.Add(PathVariable('CONFIG',
    'Path to configuration file',
    '/etc/my_config',
    PathVariable.PathIsFile))
env = Environment(variables = vars,
    CPPDEFINES={'CONFIG_FILE' : '"$CONFIG"'})
env.Program('foo.c')
```

Conversely, to ensure that any specified paths are directories and not files, use the PathVariable.PathIsDir method:
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vars = Variables('custom.py')
vars.Add(PathVariable('DBDIR',
    'Path to database directory',
    '/var/my_dbdir',
    PathVariable.PathIsDir))
env = Environment(variables = vars,
    CPPDEFINES={'DBDIR' : '"$DBDIR"'})
env.Program('foo.c')

If you want to make sure that any specified paths are directories, and you would like the directory created if it doesn’t already exist, use the PathVariable.PathIsDirCreate method:

vars = Variables('custom.py')
vars.Add(PathVariable('DBDIR',
    'Path to database directory',
    '/var/my_dbdir',
    PathVariable.PathIsDirCreate))
env = Environment(variables = vars,
    CPPDEFINES={'DBDIR' : '"$DBDIR"'})
env.Program('foo.c')

Lastly, if you don’t care whether the path exists, is a file, or a directory, use the MethodPathAccept method to accept any path that the user supplies:

vars = Variables('custom.py')
vars.Add(PathVariable('OUTPUT',
    'Path to output file or directory',
    None,
    PathVariable.PathAccept))
env = Environment(variables = vars,
    CPPDEFINES={'OUTPUT' : '"$OUTPUT"'})
env.Program('foo.c')

### 12.2.4.5. Enabled/Disabled Path Names: the PackageVariable Build Variable Function

Sometimes you want to give users even more control over a path name variable, allowing them to explicitly enable or disable the path name by using yes or no keywords, in addition to allow them to supply an explicit path name. SCons supports the PackageVariable function to support this:

vars = Variables('custom.py')
vars.Add(PackageVariable('PACKAGE',
    'Location package',
    '/opt/location'))
env = Environment(variables = vars,
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```python
CPPDEFINES=('PACKAGE' : '"$PACKAGE"')
env.Program('foo.c')
```

When the SConscript file uses the PackageVariable function, user can now still use the default or supply an overriding path name, but can now explicitly set the specified variable to a value that indicates the package should be enabled (in which case the default should be used) or disabled:

```
% scons -Q foo.o
cc -o foo.o -c -DPACKAGE="/opt/location" foo.c
% scons -Q PACKAGE="/usr/local/location" foo.o
cc -o foo.o -c -DPACKAGE="/usr/local/location" foo.c
% scons -Q PACKAGE=yes foo.o
cc -o foo.o -c -DPACKAGE="True" foo.c
% scons -Q PACKAGE=no foo.o
cc -o foo.o -c -DPACKAGE="False" foo.c
```

### 12.2.5. Adding Multiple Command-Line Build Variables at Once

Lastly, SCons provides a way to add multiple build variables to a Variables object at once. Instead of having to call the Add method multiple times, you can call the AddVariables method with a list of build variables to be added to the object. Each build variable is specified as either a tuple of arguments, just like you’d pass to the Add method itself, or as a call to one of the pre-defined functions for pre-packaged command-line build variables, in any order:

```python
vars = Variables()
vars.AddVariables(
    ('RELEASE', 'Set to 1 to build for release', 0),
    ('CONFIG', 'Configuration file', '/etc/my_config'),
    BoolVariable('warnings', 'compilation with -Wall and similar', 1),
    EnumVariable('debug', 'debug output and symbols', 'no',
                 allowed_values=('yes', 'no', 'full'),
                 map={}, ignorecase=0),  # case sensitive
    ListVariable('shared',
                 'libraries to build as shared libraries',
                 'all',
                 names = list_of_libs),
    PackageVariable('x11',
                    'use X11 installed here (yes = search some places)',
                    'yes'),
    PathVariable('qtdir', 'where the root of Qt is installed', qtdir),
)
```
12.2.6. Handling Unknown Command-Line Build Variables: the UnknownVariables Function

Users may, of course, occasionally misspell variable names in their command-line settings. SCons does not generate an error or warning for any unknown variables the users specifies on the command line. (This is in no small part because you may be processing the arguments directly using the ARGUMENTS dictionary, and therefore SCons can’t know in the general case whether a given "misspelled" variable is really unknown and a potential problem, or something that your SConscript file will handle directly with some Python code.)

If, however, you’re using a Variables object to define a specific set of command-line build variables that you expect users to be able to set, you may want to provide an error message or warning of your own if the user supplies a variable setting that is not among the defined list of variable names known to the Variables object. You can do this by calling the UnknownVariables method of the Variables object:

```python
vars = Variables(None)
vars.Add('RELEASE', 'Set to 1 to build for release', 0)
env = Environment(variables = vars,
                   CPPDEFINES={'RELEASE_BUILD' : '${RELEASE}')
unknown = vars.UnknownVariables()
if unknown:
    print "Unknown variables:", unknown.keys()
    Exit(1)
env.Program('foo.c')
```

The UnknownVariables method returns a dictionary containing the keywords and values of any variables the user specified on the command line that are not among the variables known to the Variables object (from having been specified using the Variables object’s Add method). In the example above, we check for whether the dictionary returned by the UnknownVariables is non-empty, and if so print the Python list containing the names of the unknown variables and then call the Exit function to terminate SCons:

```
% scons -Q NOT_KNOWN=foo
Unknown variables: ['NOT_KNOWN']
```

Of course, you can process the items in the dictionary returned by the UnknownVariables function in any way appropriate to your build configuration, including just printing a warning message but not exiting, logging an error somewhere, etc.

Note that you must delay the call of UnknownVariables until after you have applied the Variables object to a construction environment with the variables= keyword argument of an Environment call.
12.3. Command-Line Targets

12.3.1. Fetching Command-Line Targets: the COMMAND_LINE_TARGETS Variable

SCons supports a COMMAND_LINE_TARGETS variable that lets you fetch the list of targets that the user specified on the command line. You can use the targets to manipulate the build in any way you wish. As a simple example, suppose that you want to print a reminder to the user whenever a specific program is built. You can do this by checking for the target in the COMMAND_LINE_TARGETS list:

```python
if 'bar' in COMMAND_LINE_TARGETS:
    print "Don’t forget to copy ‘bar’ to the archive!"
Default(Program('foo.c'))
Program('bar.c')
```

Then, running SCons with the default target works as it always does, but explicitly specifying the bar target on the command line generates the warning message:

```
% scons -Q
cc -o foo.o -c foo.c
cc -o foo foo.o
% scons -Q bar
Don’t forget to copy ‘bar’ to the archive!
cc -o bar.o -c bar.c
cc -o bar bar.o
```

Another practical use for the COMMAND_LINE_TARGETS variable might be to speed up a build by only reading certain subsidiary SConscript files if a specific target is requested.

12.3.2. Controlling the Default Targets: the Default Function

One of the most basic things you can control is which targets SCons will build by default—that is, when there are no targets specified on the command line. As mentioned previously, SCons will normally build every target in or below the current directory by default—that is, when you don’t explicitly specify one or more targets on the command line. Sometimes, however, you may want to specify explicitly that only certain programs, or programs in certain directories, should be built by default. You do this with the Default function:

```python
env = Environment()
hello = env.Program('hello.c')
env.Program('goodbye.c')
Default(hello)
```
This SConstruct file knows how to build two programs, hello and goodbye, but only builds the hello program by default:

```
% scons -Q
cc -o hello.o -c hello.c
cc -o hello hello.o
% scons -Q
scons: 'hello' is up to date.
% scons -Q goodbye
cc -o goodbye.o -c goodbye.c
cc -o goodbye goodbye.o
```

Note that, even when you use the Default function in your SConstruct file, you can still explicitly specify the current directory (.) on the command line to tell SCons to build everything in (or below) the current directory:

```
% scons -Q .
cc -o goodbye.o -c goodbye.c
cc -o goodbye goodbye.o
cc -o hello.o -c hello.c
cc -o hello hello.o
```

You can also call the Default function more than once, in which case each call adds to the list of targets to be built by default:

```
env = Environment()
prog1 = env.Program('prog1.c')
Default(prog1)
prog2 = env.Program('prog2.c')
prog3 = env.Program('prog3.c')
Default(prog3)
```

Or you can specify more than one target in a single call to the Default function:

```
env = Environment()
prog1 = env.Program('prog1.c')
prog2 = env.Program('prog2.c')
prog3 = env.Program('prog3.c')
Default(prog1, prog3)
```

Either of these last two examples will build only the prog1 and prog3 programs by default:

```
% scons -Q
cc -o prog1.o -c prog1.c
cc -o prog1 prog1.o
cc -o prog3.o -c prog3.c
```
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cc -o prog3 prog3.o
% scons -Q .
c -o prog2.o -c prog2.c
c -o prog2 prog2.o

You can list a directory as an argument to Default:

```python
env = Environment()
env.Program(['prog1/main.c', 'prog1/foo.c'])
env.Program(['prog2/main.c', 'prog2/bar.c'])
Default('prog1')
```

In which case only the target(s) in that directory will be built by default:

```bash
% scons -Q
cc -o prog1/foo.o -c prog1/foo.c
cc -o prog1/main.o -c prog1/main.c
cc -o prog1/main prog1/main.o prog1/foo.o
% scons -Q
scons: 'prog1' is up to date.
% scons -Q .
cc -o prog2/bar.o -c prog2/bar.c
cc -o prog2/main.o -c prog2/main.c
cc -o prog2/main prog2/main.o prog2/bar.o
```

Lastly, if for some reason you don’t want any targets built by default, you can use the Python `None` variable:

```python
env = Environment()
prog1 = env.Program('prog1.c')
prog2 = env.Program('prog2.c')
Default(None)
```

Which would produce build output like:

```bash
% scons -Q
scons: *** No targets specified and no Default() targets found. Stop.
% scons -Q .
c -o prog1.o -c prog1.c
cc -o prog1 prog1.o
cc -o prog2.o -c prog2.c
cc -o prog2 prog2.o
```
12.3.2.1. Fetching the List of Default Targets: the DEFAULT_TARGETS Variable

SCons supports a DEFAULT_TARGETS variable that lets you get at the current list of default targets. The DEFAULT_TARGETS variable has two important differences from the COMMAND_LINE_TARGETS variable. First, the DEFAULT_TARGETS variable is a list of internal SCons nodes, so you need to convert the list elements to strings if you want to print them or look for a specific target name. Fortunately, you can do this easily by using the Python `map` function to run the list through `str`:

```python
prog1 = Program('prog1.c')
Default(prog1)
print "DEFAULT_TARGETS is", map(str, DEFAULT_TARGETS)
```

(Keep in mind that all of the manipulation of the DEFAULT_TARGETS list takes place during the first phase when SCons is reading up the SConscript files, which is obvious if we leave off the `-Q` flag when we run SCons:)

```bash
% scons
scons: Reading SConscript files ...
DEFAULT_TARGETS is ['prog1']
scons: done reading SConscript files.
scons: Building targets ...
cc -o prog1.o -c prog1.c
cc -o prog1 prog1.o
scons: done building targets.
```

Second, the contents of the DEFAULT_TARGETS list change in response to calls to the Default function, as you can see from the following SConstruct file:

```python
prog1 = Program('prog1.c')
Default(prog1)
print "DEFAULT_TARGETS is now", map(str, DEFAULT_TARGETS)
prog2 = Program('prog2.c')
Default(prog2)
print "DEFAULT_TARGETS is now", map(str, DEFAULT_TARGETS)
```

Which yields the output:

```bash
% scons
scons: Reading SConscript files ...
DEFAULT_TARGETS is now ['prog1']
DEFAULT_TARGETS is now ['prog1', 'prog2']
scons: done reading SConscript files.
scons: Building targets ...
cc -o prog1.o -c prog1.c
cc -o prog1 prog1.o
```

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cc -o prog2.o -c prog2.c
cc -o prog2 prog2.o
scons: done building targets.

In practice, this simply means that you need to pay attention to the order in which you call the `Default` function and refer to the `DEFAULT_TARGETS` list, to make sure that you don’t examine the list before you’ve added the default targets you expect to find in it.

12.3.3. Fetching the List of Build Targets, Regardless of Origin: the BUILD_TARGETS Variable

We’ve already been introduced to the `COMMAND_LINE_TARGETS` variable, which contains a list of targets specified on the command line, and the `DEFAULT_TARGETS` variable, which contains a list of targets specified via calls to the `Default` method or function. Sometimes, however, you want a list of whatever targets SCons will try to build, regardless of whether the targets came from the command line or a `Default` call. You could code this up by hand, as follows:

```python
if COMMAND_LINE_TARGETS:
    targets = COMMAND_LINE_TARGETS
else:
    targets = DEFAULT_TARGETS
```

SCons, however, provides a convenient `BUILD_TARGETS` variable that eliminates the need for this by-hand manipulation. Essentially, the `BUILD_TARGETS` variable contains a list of the command-line targets, if any were specified, and if no command-line targets were specified, it contains a list of the targets specified via the `Default` method or function.

Because `BUILD_TARGETS` may contain a list of SCons nodes, you must convert the list elements to strings if you want to print them or look for a specific target name, just like the `DEFAULT_TARGETS` list:

```python
prog1 = Program('prog1.c')
Program('prog2.c')
Default(prog1)
print "BUILD_TARGETS is", map(str, BUILD_TARGETS)
```

Notice how the value of `BUILD_TARGETS` changes depending on whether a target is specified on the command line:

```
% scons -Q
BUILD_TARGETS is ['prog1']
c -o prog1.o -c prog1.c
cc -o prog1 prog1.o
```
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% scons -Q prog2
BUILD_TARGETS is ['prog2']
c -o prog2.o -c prog2.c
c -o prog2 prog2.o
% scons -Q -c .
BUILD_TARGETS is ['.']
Removed prog1.o
Removed prog1
Removed prog2.o
Removed prog2

Notes

1. The AddOption function is, in fact, implemented using a subclass of the optparse.OptionParser.
Chapter 13. Installing Files in Other Directories: the Install Builder

Once a program is built, it is often appropriate to install it in another directory for public use. You use the `Install` method to arrange for a program, or any other file, to be copied into a destination directory:

```python
env = Environment()
hello = env.Program('hello.c')
env.Install('/usr/bin', hello)
```

Note, however, that installing a file is still considered a type of file "build." This is important when you remember that the default behavior of SCons is to build files in or below the current directory. If, as in the example above, you are installing files in a directory outside of the top-level `SConstruct` file's directory tree, you must specify that directory (or a higher directory, such as `/`) for it to install anything there:

```bash
% scons -Q
cc -o hello.o -c hello.c
cc -o hello hello.o
% scons -Q /usr/bin
Install file: "hello" as "/usr/bin/hello"
```

It can, however, be cumbersome to remember (and type) the specific destination directory in which the program (or any other file) should be installed. This is an area where the `Alias` function comes in handy, allowing you, for example, to create a pseudo-target named `install` that can expand to the specified destination directory:

```python
env = Environment()
hello = env.Program('hello.c')
env.Install('/usr/bin', hello)
env.Alias('install', '/usr/bin')
```

This then yields the more natural ability to install the program in its destination as follows:

```bash
% scons -Q
cc -o hello.o -c hello.c
cc -o hello hello.o
% scons -Q install
Install file: "hello" as "/usr/bin/hello"
```
Chapter 13. Installing Files in Other Directories: the Install Builder

13.1. Installing Multiple Files in a Directory

You can install multiple files into a directory simply by calling the Install function multiple times:

```python
env = Environment()
hello = env.Program('hello.c')
goodbye = env.Program('goodbye.c')
env.Install('/usr/bin', hello)
env.Install('/usr/bin', goodbye)
env.Alias('install', '/usr/bin')
```

Or, more succinctly, listing the multiple input files in a list (just like you can do with any other builder):

```python
env = Environment()
hello = env.Program('hello.c')
goodbye = env.Program('goodbye.c')
env.Install('/usr/bin', [hello, goodbye])
env.Alias('install', '/usr/bin')
```

Either of these two examples yields:

```
% scons -Q install
cc -o goodbye.o -c goodbye.c
cc -o goodbye goodbye.o
Install file: "goodbye" as "/usr/bin/goodbye"
cc -o hello.o -c hello.c
cc -o hello hello.o
Install file: "hello" as "/usr/bin/hello"
```

13.2. Installing a File Under a Different Name

The Install method preserves the name of the file when it is copied into the destination directory. If you need to change the name of the file when you copy it, use the InstallAs function:

```python
env = Environment()
hello = env.Program('hello.c')
env.InstallAs('/usr/bin/hello-new', hello)
env.Alias('install', '/usr/bin')
```

This installs the hello program with the name hello-new as follows:

```
% scons -Q install
cc -o hello.o -c hello.c
```
Chapter 13. Installing Files in Other Directories: the Install Builder

cc -o hello hello.o
Install file: "hello" as "/usr/bin/hello-new"

13.3. Installing Multiple Files Under Different Names

Lastly, if you have multiple files that all need to be installed with different file names, you can either call the InstallAs function multiple times, or as a shorthand, you can supply same-length lists for both the target and source arguments:

```
env = Environment()
hello = env.Program('hello.c')
goodbye = env.Program('goodbye.c')
env.InstallAs(['/usr/bin/hello-new',
               '/usr/bin/goodbye-new'],
              [hello, goodbye])
env.Alias('install', '/usr/bin')
```

In this case, the InstallAs function loops through both lists simultaneously, and copies each source file into its corresponding target file name:

```
% scons -Q install
cc -o goodbye.o -c goodbye.c
cc -o goodbye goodbye.o
Install file: "goodbye" as "/usr/bin/goodbye-new"
cc -o hello.o -c hello.c
cc -o hello hello.o
Install file: "hello" as "/usr/bin/hello-new"
```
Chapter 14. Platform-Independent File System Manipulation

SCons provides a number of platform-independent functions, called factories, that perform common file system manipulations like copying, moving or deleting files and directories, or making directories. These functions are factories because they don’t perform the action at the time they’re called, they each return an Action object that can be executed at the appropriate time.

14.1. Copying Files or Directories: The copy Factory

Suppose you want to arrange to make a copy of a file, and don’t have a suitable pre-existing builder. One way would be to use the copy action factory in conjunction with the Command builder:

```
Command("file.out", "file.in", Copy("$TARGET", "$SOURCE"))
```

Notice that the action returned by the Copy factory will expand the $TARGET and $SOURCE strings at the time file.out is built, and that the order of the arguments is the same as that of a builder itself—that is, target first, followed by source:

```
% scons -Q
Copy("file.out", "file.in")
```

You can, of course, name a file explicitly instead of using $TARGET or $SOURCE:

```
Command("file.out", [], Copy("$TARGET", "file.in"))
```

Which executes as:

```
% scons -Q
Copy("file.out", "file.in")
```

The usefulness of the Copy factory becomes more apparent when you use it in a list of actions passed to the Command builder. For example, suppose you needed to run a file through a utility that only modifies files in-place, and can’t "pipe" input to output. One solution is to copy the source file to a temporary file name, run the utility, and then copy the modified temporary file to the target, which the Copy factory makes extremely easy:

```
Command("file.out", "file.in",
    []
) # This does nothing except declare a new Action
```
The output then looks like:

```sh
% scons -Q
Copy("tempfile", "file.in")
modify tempfile
Copy("file.out", "tempfile")
```

### 14.2. Deleting Files or Directories: The Delete Factory

If you need to delete a file, then the Delete factory can be used in much the same way as the Copy factory. For example, if we want to make sure that the temporary file in our last example doesn’t exist before we copy to it, we could add Delete to the beginning of the command list:

```
Command("file.out", "file.in",
[  
  Delete("tempfile"),
  Copy("tempfile", "$SOURCE"),
  "modify tempfile",
  Copy("TARGET", "tempfile"),
])
```

When then executes as follows:

```sh
% scons -Q
Delete("tempfile")
Copy("tempfile", "file.in")
modify tempfile
Copy("file.out", "tempfile")
```

Of course, like all of these Action factories, the Delete factory also expands $TARGET and $SOURCE variables appropriately. For example:

```
Command("file.out", "file.in",
[  
  Delete("TARGET"),
  Copy("TARGET", "$SOURCE")
])
```
Chapter 14. Platform-Independent File System Manipulation

Executes as:

```bash
% scons -Q
Delete("file.out")
Copy("file.out", "file.in")
```

Note, however, that you typically don’t need to call the `Delete` factory explicitly in this way; by default, SCons deletes its target(s) for you before executing any action.

One word of caution about using the `Delete` factory: it has the same variable expansions available as any other factory, including the `$SOURCE` variable. Specifying `Delete("$SOURCE")` is not something you usually want to do!

### 14.3. Moving (Renaming) Files or Directories: The `Move` Factory

The `Move` factory allows you to rename a file or directory. For example, if we don’t want to copy the temporary file, we could use:

```bash
Command("file.out", "file.in",
    [Copy("tempfile", "$SOURCE"),
     "modify tempfile",
     Move("$TARGET", "tempfile"),
    ])
```

Which would execute as:

```bash
% scons -Q
Copy("tempfile", "file.in")
modify tempfile
Move("file.out", "tempfile")
```

### 14.4. Updating the Modification Time of a File: The `Touch` Factory

If you just need to update the recorded modification time for a file, use the `Touch` factory:

```bash
Command("file.out", "file.in",
```
[Copy("$TARGET", "$SOURCE"),
 Touch("$TARGET"),
]

Which executes as:

% scons -Q
Copy("file.out", "file.in")
Touch("file.out")

14.5. Creating a Directory: The Mkdir Factory

If you need to create a directory, use the Mkdir factory. For example, if we need to process a file in a temporary directory in which the processing tool will create other files that we don’t care about, you could use:

Command("file.out", "file.in",
 [Delete("tempdir"),
 Mkdir("tempdir"),
 Copy("tempdir/${SOURCE.file}"", "$SOURCE"),
 "process tempdir",
 Move("$TARGET", "tempdir/output_file"),
 Delete("tempdir"),
])

Which executes as:

% scons -Q
Delete("tempdir")
Mkdir("tempdir")
Copy("tempdir/file.in", "file.in")
process tempdir
Move("file.out", "tempdir/output_file")
scons: *** [file.out] No such file or directory
14.6. Changing File or Directory Permissions: The Chmod Factory

To change permissions on a file or directory, use the Chmod factory. The permission argument uses POSIX-style permission bits and should typically be expressed as an octal, not decimal, number:

```
Command("file.out", "file.in",
    [Copy("$TARGET", "$SOURCE"),
     Chmod("$TARGET", 0755),
    ]
)
```

Which executes:

```
% scons -Q
Copy("file.out", "file.in")
Chmod("file.out", 0755)
```

14.7. Executing an action immediately: the Execute Function

We’ve been showing you how to use Action factories in the Command function. You can also execute an Action returned by a factory (or actually, any Action) at the time the SConscript file is read by using the Execute function. For example, if we need to make sure that a directory exists before we build any targets,

```
Execute(Mkdir('/tmp/my_temp_directory'))
```

Notice that this will create the directory while the SConscript file is being read:

```
% scons
scons: Reading SConscript files ...
Mkdir("/tmp/my_temp_directory")
scons: done reading SConscript files.
scons: Building targets ...
scons: ‘.’ is up to date.
scons: done building targets.
```

If you’re familiar with Python, you may wonder why you would want to use this instead of just calling the native Python os.mkdir() function. The advantage here is that the Mkdir action will behave
appropriately if the user specifies the SCons \(-n\) or \(-q\) options—that is, it will print the action but not actually make the directory when \(-n\) is specified, or make the directory but not print the action when \(-q\) is specified.

The \texttt{Execute} function returns the exit status or return value of the underlying action being executed. It will also print an error message if the action fails and returns a non-zero value. SCons will \textit{not}, however, actually stop the build if the action fails. If you want the build to stop in response to a failure in an action called by \texttt{Execute}, you must do so by explicitly checking the return value and calling the \texttt{Exit} function (or a Python equivalent):

```python
if Execute(Mkdir('/tmp/my_temp_directory')):
    # A problem occurred while making the temp directory.
    Exit(1)
```

\section*{Notes}

1. Unfortunately, in the early days of SCons design, we used the name \texttt{Copy} for the function that returns a copy of the environment, otherwise that would be the logical choice for a Builder that copies a file or directory tree to a target location.
Chapter 15. Controlling Removal of Targets

There are two occasions when SCons will, by default, remove target files. The first is when SCons determines that an target file needs to be rebuilt and removes the existing version of the target before executing it. The second is when SCons is invoked with the -c option to "clean" a tree of its built targets. These behaviors can be suppressed with the Precious and NoClean functions, respectively.

15.1. Preventing target removal during build: the Precious Function

By default, SCons removes targets before building them. Sometimes, however, this is not what you want. For example, you may want to update a library incrementally, not by having it deleted and then rebuilt from all of the constituent object files. In such cases, you can use the Precious method to prevent SCons from removing the target before it is built:

```python
env = Environment(RANLIBCOM="
lib = env.Library('foo', ['f1.c', 'f2.c', 'f3.c'])
env.Precious(lib)
```

Although the output doesn’t look any different, SCons does not, in fact, delete the target library before rebuilding it:

```
% scons -Q
cc -o f1.o -c f1.c
cc -o f2.o -c f2.c
cc -o f3.o -c f3.c
ar rc libfoo.a f1.o f2.o f3.o
```

SCons will, however, still delete files marked as Precious when the -c option is used.

15.2. Preventing target removal during clean: the NoClean Function

By default, SCons removes all built targets when invoked with the -c option to clean a source tree of built targets. Sometimes, however, this is not what you want. For example, you may want to remove only intermediate generated files (such as object files), but leave the final targets (the libraries) untouched. In such cases, you can use the NoClean method to prevent SCons from removing a target during a clean:

```python
env = Environment(RANLIBCOM="")
```
Chapter 15. Controlling Removal of Targets

```python
lib = env.Library('foo', ['f1.c', 'f2.c', 'f3.c'])
env.NoClean(lib)
```

Notice that the `libfoo.a` is not listed as a removed file:

```
% scons -Q
cc -o f1.o -c f1.c
c -o f2.o -c f2.c
c -o f3.o -c f3.c
ar rc libfoo.a f1.o f2.o f3.o
% scons -c
scons: Reading SConscript files ...  
scons: done reading SConscript files.  
scons: Cleaning targets ...  
Removed f1.o  
Removed f2.o  
Removed f3.o  
scons: done cleaning targets.
```

15.3. Removing additional files during clean: the `Clean` Function

There may be additional files that you want removed when the `-c` option is used, but which SCons doesn’t know about because they’re not normal target files. For example, perhaps a command you invoke creates a log file as part of building the target file you want. You would like the log file cleaned, but you don’t want to have to teach SCons that the command "builds" two files.

You can use the `Clean` function to arrange for additional files to be removed when the `-c` option is used. Notice, however, that the `Clean` function takes two arguments, and the second argument is the name of the additional file you want cleaned (`foo.log` in this example):

```python
t = Command('foo.out', 'foo.in', 'build -o $TARGET $SOURCE')
Clean(t, 'foo.log')
```

The first argument is the target with which you want the cleaning of this additional file associated. In the above example, we’ve used the return value from the `Command` function, which represents the `foo.out` target. Now whenever the `foo.out` target is cleaned by the `-c` option, the `foo.log` file will be removed as well:

```
% scons -Q
build -o foo.out foo.in
% scons -Q -c
Removed foo.out
```
Chapter 15. Controlling Removal of Targets

Removed foo.log
Chapter 16. Hierarchical Builds

The source code for large software projects rarely stays in a single directory, but is nearly always divided into a hierarchy of directories. Organizing a large software build using SCons involves creating a hierarchy of build scripts using the SConscript function.

16.1. SConscript Files

As we’ve already seen, the build script at the top of the tree is called SConstruct. The top-level SConstruct file can use the SConscript function to include other subsidiary scripts in the build. These subsidiary scripts can, in turn, use the SConscript function to include still other scripts in the build. By convention, these subsidiary scripts are usually named SConscript. For example, a top-level SConstruct file might arrange for four subsidiary scripts to be included in the build as follows:

SConscript(['drivers/display/SConscript',
            'drivers/mouse/SConscript',
            'parser/SConscript',
            'utilities/SConscript'])

In this case, the SConstruct file lists all of the SConscript files in the build explicitly. (Note, however, that not every directory in the tree necessarily has an SConscript file.) Alternatively, the drivers subdirectory might contain an intermediate SConscript file, in which case the SConscript call in the top-level SConstruct file would look like:

SConscript(['drivers/SConscript',
            'parser/SConscript',
            'utilities/SConscript'])

And the subsidiary SConscript file in the drivers subdirectory would look like:

SConscript(['display/SConscript',
            'mouse/SConscript'])

Whether you list all of the SConscript files in the top-level SConstruct file, or place a subsidiary SConscript file in intervening directories, or use some mix of the two schemes, is up to you and the needs of your software.
16.2. Path Names Are Relative to the SConscript Directory

Subsidiary SConscript files make it easy to create a build hierarchy because all of the file and directory names in a subsidiary SConscript files are interpreted relative to the directory in which the SConscript file lives. Typically, this allows the SConscript file containing the instructions to build a target file to live in the same directory as the source files from which the target will be built, making it easy to update how the software is built whenever files are added or deleted (or other changes are made).

For example, suppose we want to build two programs prog1 and prog2 in two separate directories with the same names as the programs. One typical way to do this would be with a top-level SConstruct file like this:

```python
SConscript(['prog1/SConscript',
           'prog2/SConscript'])
```

And subsidiary SConscript files that look like this:

```python
env = Environment()
env.Program('prog1', ['main.c', 'foo1.c', 'foo2.c'])
```

And this:

```python
env = Environment()
env.Program('prog2', ['main.c', 'bar1.c', 'bar2.c'])
```

Then, when we run SCons in the top-level directory, our build looks like:

```
% scons -Q
  cc -o prog1/foo1.o -c prog1/foo1.c
  cc -o prog1/foo2.o -c prog1/foo2.c
  cc -o prog1/main.o -c prog1/main.c
  cc -o prog1/prog1 prog1/main.o prog1/foo1.o prog1/foo2.o
  cc -o prog2/bar1.o -c prog2/bar1.c
  cc -o prog2/bar2.o -c prog2/bar2.c
  cc -o prog2/main.o -c prog2/main.c
  cc -o prog2/prog2 prog2/main.o prog2/bar1.o prog2/bar2.o
```

Notice the following: First, you can have files with the same names in multiple directories, like main.c in the above example. Second, unlike standard recursive use of Make, SCons stays in the top-level directory (where the SConstruct file lives) and issues commands that use the path names from the top-level directory to the target and source files within the hierarchy.
16.3. Top-Level Path Names in Subsidiary SConscript Files

If you need to use a file from another directory, it’s sometimes more convenient to specify the path to a file in another directory from the top-level SConstruct directory, even when you’re using that file in a subsidiary SConscript file in a subdirectory. You can tell SCons to interpret a path name as relative to the top-level SConstruct directory, not the local directory of the SConscript file, by appending a # (hash mark) to the beginning of the path name:

```python
env = Environment()
env.Program('prog', ['main.c', '#lib/foo1.c', 'foo2.c'])
```

In this example, the lib directory is directly underneath the top-level SConstruct directory. If the above SConscript file is in a subdirectory named src/prog, the output would look like:

```bash
% scons -Q
cc -o lib/foo1.o -c lib/foo1.c
cc -o src/prog/foo2.o -c src/prog/foo2.c
cc -o src/prog/main.o -c src/prog/main.c
cc -o src/prog/prog src/prog/main.o lib/foo1.o src/prog/foo2.o
```

(Notice that the lib/foo1.o object file is built in the same directory as its source file. See Chapter 17, below, for information about how to build the object file in a different subdirectory.)

16.4. Absolute Path Names

Of course, you can always specify an absolute path name for a file--for example:

```python
env = Environment()
env.Program('prog', ['main.c', '/usr/joe/lib/foo1.c', 'foo2.c'])
```

Which, when executed, would yield:

```bash
% scons -Q
cc -o src/prog/foo2.o -c src/prog/foo2.c
cc -o src/prog/main.o -c src/prog/main.c
cc -o /usr/joe/lib/foo1.o -c /usr/joe/lib/foo1.c
cc -o src/prog/prog src/prog/main.o /usr/joe/lib/foo1.o src/prog/foo2.o
```
Chapter 16. Hierarchical Builds

(As was the case with top-relative path names, notice that the /usr/joe/lib/foo1.o object file is built in the same directory as its source file. See Chapter 17, below, for information about how to build the object file in a different subdirectory.)

16.5. Sharing Environments (and Other Variables) Between SConscript Files

In the previous example, each of the subsidiary SConscript files created its own construction environment by calling Environment separately. This obviously works fine, but if each program must be built with the same construction variables, it’s cumbersome and error-prone to initialize separate construction environments in the same way over and over in each subsidiary SConscript file.

SCons supports the ability to export variables from a parent SConscript file to its subsidiary SConscript files, which allows you to share common initialized values throughout your build hierarchy.

16.5.1. Exporting Variables

There are two ways to export a variable, such as a construction environment, from an SConscript file, so that it may be used by other SConscript files. First, you can call the Export function with a list of variables, or a string of white-space separated variable names. Each call to Export adds one or more variables to a global list of variables that are available for import by other SConscript files.

```
env = Environment()
Export('env')
```

You may export more than one variable name at a time:

```
env = Environment()
d = ARGUMENTS['debug']
Export('env', 'debug')
```

Because white space is not legal in Python variable names, the Export function will even automatically split a string into separate names for you:

```
Export('env debug')
```

Second, you can specify a list of variables to export as a second argument to the SConscript function call:

```
SConscript('src/SConscript', 'env')
```
Or as the \texttt{exports} keyword argument:

\begin{verbatim}
SConscript('src/SConscript', exports='env')
\end{verbatim}

These calls export the specified variables to only the listed \texttt{SConscript} files. You may, however, specify more than one \texttt{SConscript} file in a list:

\begin{verbatim}
SConscript(['src1/SConscript',
            'src2/SConscript'], exports='env')
\end{verbatim}

This is functionally equivalent to calling the \texttt{SConscript} function multiple times with the same \texttt{exports} argument, one per \texttt{SConscript} file.

### 16.5.2. Importing Variables

Once a variable has been exported from a calling \texttt{SConscript} file, it may be used in other \texttt{SConscript} files by calling the \texttt{Import} function:

\begin{verbatim}
Import('env')
env.Program('prog', ['prog.c'])
\end{verbatim}

The \texttt{Import} call makes the \texttt{env} construction environment available to the \texttt{SConscript} file, after which the variable can be used to build programs, libraries, etc.

Like the \texttt{Export} function, the \texttt{Import} function can be used with multiple variable names:

\begin{verbatim}
Import('env', 'debug')
env = env.Clone(DEBUG = debug)
env.Program('prog', ['prog.c'])
\end{verbatim}

And the \texttt{Import} function will similarly split a string along white-space into separate variable names:

\begin{verbatim}
Import('env debug')
env = env.Clone(DEBUG = debug)
env.Program('prog', ['prog.c'])
\end{verbatim}

Lastly, as a special case, you may import all of the variables that have been exported by supplying an asterisk to the \texttt{Import} function:
Chapter 16. Hierarchical Builds

```python
Import('*')
env = env.Clone(DEBUG = debug)
env.Program('prog', ['prog.c'])
```

If you’re dealing with a lot of SConscript files, this can be a lot simpler than keeping arbitrary lists of imported variables in each file.

### 16.5.3. Returning Values From an SConscript File

Sometimes, you would like to be able to use information from a subsidiary SConscript file in some way. For example, suppose that you want to create one library from source files scattered throughout a number of subsidiary SConscript files. You can do this by using the `Return` function to return values from the subsidiary SConscript files to the calling file.

If, for example, we have two subdirectories `foo` and `bar` that should each contribute a source file to a Library, what we’d like to be able to do is collect the object files from the subsidiary SConscript calls like this:

```python
env = Environment()
Export('env')
objs = []
for subdir in ['foo', 'bar']:
    o = SConscript('%s/SConscript' % subdir)
    objs.append(o)
env.Library('prog', objs)
```

We can do this by using the `Return` function in the `foo/SConscript` file like this:

```python
Import('env')
obj = env.Object('foo.c')
Return('obj')
```

(The corresponding `bar/SConscript` file should be pretty obvious.) Then when we run SCons, the object files from the subsidiary subdirectories are all correctly archived in the desired library:

```
% scons -Q
cc -o bar/bar.o -c bar/bar.c
cc -o foo/foo.o -c foo/foo.c
ar rc libprog.a foo/foo.o bar/bar.o
ranlib libprog.a
```
Chapter 17. Separating Source and Build Directories

It’s often useful to keep any built files completely separate from the source files. In SCons, this is usually done by creating one or more separate variant directory trees that are used to hold the built objects files, libraries, and executable programs, etc. for a specific flavor, or variant, of build. SCons provides two ways to do this, one through the SConscript function that we’ve already seen, and the second through a more flexible VariantDir function.

One historical note: the VariantDir function used to be called BuildDir. That name is still supported but has been deprecated because the SCons functionality differs from the model of a “build directory” implemented by other build systems like the GNU Autotools.

17.1. Specifying a Variant Directory Tree as Part of an SConscript Call

The most straightforward way to establish a variant directory tree uses the fact that the usual way to set up a build hierarchy is to have an SConscript file in the source subdirectory. If you then pass a variant_dir argument to the SConscript function call:

```python
SConscript('src/SConscript', variant_dir='build')
```

SCons will then build all of the files in the build subdirectory:

```bash
% ls src
SConscript  hello.c
% scons -Q
cc -o build/hello.o -c build/hello.c
cc -o build/hello build/hello.o
% ls build
SConscript  hello  hello.c  hello.o
```

But wait a minute--what’s going on here? SCons created the object file build/hello.o in the build subdirectory, as expected. But even though our hello.c file lives in the src subdirectory, SCons has actually compiled a build/hello.c file to create the object file.

What’s happened is that SCons has duplicated the hello.c file from the src subdirectory to the build subdirectory, and built the program from there. The next section explains why SCons does this.
17.2. Why SCons Duplicates Source Files in a Variant Directory Tree

SCons duplicates source files in variant directory trees because it’s the most straightforward way to guarantee a correct build regardless of include-file directory paths, relative references between files, or tool support for putting files in different locations, and the SCons philosophy is to, by default, guarantee a correct build in all cases.

The most direct reason to duplicate source files in variant directories is simply that some tools (mostly older versions) are written to only build their output files in the same directory as the source files. In this case, the choices are either to build the output file in the source directory and move it to the variant directory, or to duplicate the source files in the variant directory.

Additionally, relative references between files can cause problems if we don’t just duplicate the hierarchy of source files in the variant directory. You can see this at work in use of the C preprocessor `#include` mechanism with double quotes, not angle brackets:

```
#include "file.h"
```

The *de facto* standard behavior for most C compilers in this case is to first look in the same directory as the source file that contains the `#include` line, then to look in the directories in the preprocessor search path. Add to this that the SCons implementation of support for code repositories (described below) means not all of the files will be found in the same directory hierarchy, and the simplest way to make sure that the right include file is found is to duplicate the source files into the variant directory, which provides a correct build regardless of the original location(s) of the source files.

Although source-file duplication guarantees a correct build even in these end-cases, it can usually be safely disabled. The next section describes how you can disable the duplication of source files in the variant directory.

17.3. Telling SCons to Not Duplicate Source Files in the Variant Directory Tree

In most cases and with most tool sets, SCons can place its target files in a build subdirectory without duplicating the source files and everything will work just fine. You can disable the default SCons behavior by specifying `duplicate=0` when you call the `SConscript` function:

```
SConscript(‘src/SConscript’, variant_dir=’build’, duplicate=0)
```
When this flag is specified, SCons uses the variant directory like most people expect—that is, the output files are placed in the variant directory while the source files stay in the source directory:

```
% ls src
SConscript
hello.c
% scons -Q
cc -c src/hello.c -o build/hello.o
cc -o build/hello build/hello.o
% ls build
hello
hello.o
```

### 17.4. The `VariantDir` Function

Use the `VariantDir` function to establish that target files should be built in a separate directory from the source files:

```python
VariantDir('build', 'src')
env = Environment()
env.Program('build/hello.c')
```

Note that when you’re not using an `SConscript` file in the `src` subdirectory, you must actually specify that the program must be built from the `build/hello.c` file that SCons will duplicate in the `build` subdirectory.

When using the `VariantDir` function directly, SCons still duplicates the source files in the variant directory by default:

```
% ls src
hello.c
% scons -Q
cc -o build/hello.o -c build/hello.c
cc -o build/hello build/hello.o
% ls build
hello hello.c hello.o
```

You can specify the same `duplicate=0` argument that you can specify for an `SConscript` call:

```python
VariantDir('build', 'src', duplicate=0)
env = Environment()
env.Program('build/hello.c')
```
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In which case SCons will disable duplication of the source files:

```
% ls src
hello.c
% scons -Q
cc -o build/hello.o -c src/hello.c
cc -o build/hello build/hello.o
% ls build
hello hello.o
```

17.5. Using VariantDir With an SConscript File

Even when using the VariantDir function, it’s much more natural to use it with a subsidiary SConscript file. For example, if the src/SConscript looks like this:

```python
env = Environment()
env.Program('hello.c')
```

Then our SConstruct file could look like:

```python
VariantDir('build', 'src')
SConscript('build/SConscript')
```

Yielding the following output:

```
% ls src
SConscript hello.c
% scons -Q
cc -o build/hello.o -c build/hello.c
cc -o build/hello build/hello.o
% ls build
SConscript hello hello.c hello.o
```

Notice that this is completely equivalent to the use of SConscript that we learned about in the previous section.

17.6. Using Glob with VariantDir

The Glob file name pattern matching function works just as usual when using VariantDir. For example, if the src/SConscript looks like this:
env = Environment()
env.Program('hello', Glob('*.c'))

Then with the same SConstruct file as in the previous section, and source files f1.c and f2.c in src, we would see the following output:

```
% ls src
SConscript f1.c f2.c f2.h
% scons -Q
cc -o build/f1.o -c build/f1.c
cc -o build/f2.o -c build/f2.c
cc -o build/hello build/f1.o build/f2.o
% ls build
SConscript f1.c f1.o f2.c f2.h f2.o hello
```

The `Glob` function returns Nodes in the `build/` tree, as you’d expect.
Chapter 18. Variant Builds

The `variant_dir` keyword argument of the `SConscript` function provides everything we need to show how easy it is to create variant builds using SCons. Suppose, for example, that we want to build a program for both Windows and Linux platforms, but that we want to build it in a shared directory with separate side-by-side build directories for the Windows and Linux versions of the program.

```python
platform = ARGUMENTS.get('OS', Platform())
include = "#export/$PLATFORM/include"
lib = "#export/$PLATFORM/lib"
bin = "#export/$PLATFORM/bin"

env = Environment(PLATFORM = platform,
                  BINDIR = bin,
                  INCDIR = include,
                  LIBDIR = lib,
                  CPPPATH = [include],
                  LIBPATH = [lib],
                  LIBS = 'world')

Export('env')

env.SConscript('src/SConscript', variant_dir='build/$PLATFORM')
```

This SConstruct file, when run on a Linux system, yields:

```
% scons -Q OS=linux
Install file: "build/linux/world/world.h" as "export/linux/include/world.h"
c -o build/linux/hello/hello.o -c -Iexport/linux/include build/linux/hello/hello.c
c -o build/linux/world/world.o -c -Iexport/linux/include build/linux/world/world.c
ar rc build/linux/world/libworld.a build/linux/world/world.o
ranlib build/linux/world/libworld.a
Install file: "build/linux/world/libworld.a" as "export/linux/lib/libworld.a"
c -o build/linux/hello/build/linux/hello/hello.o -Lexport/linux/lib -lworld
Install file: "build/linux/hello/hello" as "export/linux/bin/hello"
```

The same SConstruct file on Windows would build:

```
C:\scons -Q OS=windows
Install file: "build/windows/world/world.h" as "export/windows/include/world.h"
c /Fobuild/windows\hello\hello.obj /c build/windows\hello\hello.c /nologo /Iexport\windows\include
cl /Fobuild/windows\world\world.obj /c build/windows\world\world.c /nologo /Iexport\windows\include
lib /nologo /OUT:build/windows\world\world.lib build/windows\world\world.obj
Install file: "build/windows/world/world.lib" as "export/windows/lib/world.lib"
link /nologo /OUT:build/windows\hello\hello.exe /LIBPATH:export\windows\lib world.lib build\windows\hello\hello.obj
Install file: "build/windows/hello/hello.exe" as "export/windows/bin/hello.exe"
```
Chapter 19. Writing Your Own Builders

Although SCons provides many useful methods for building common software products: programs, libraries, documents. you frequently want to be able to build some other type of file not supported directly by SCons. Fortunately, SCons makes it very easy to define your own Builder objects for any custom file types you want to build. (In fact, the SCons interfaces for creating Builder objects are flexible enough and easy enough to use that all of the the SCons built-in Builder objects are created the mechanisms described in this section.)

19.1. Writing Builders That Execute External Commands

The simplest Builder to create is one that executes an external command. For example, if we want to build an output file by running the contents of the input file through a command named foobuild, creating that Builder might look like:

```python
bld = Builder(action = 'foobuild < $SOURCE > $TARGET')
```

All the above line does is create a free-standing Builder object. The next section will show us how to actually use it.

19.2. Attaching a Builder to a Construction Environment

A Builder object isn’t useful until it’s attached to a construction environment so that we can call it to arrange for files to be built. This is done through the $BUILDERS construction variable in an environment. The $BUILDERS variable is a Python dictionary that maps the names by which you want to call various Builder objects to the objects themselves. For example, if we want to call the Builder we just defined by the name Foo, our SConstruct file might look like:

```python
bld = Builder(action = 'foobuild < $SOURCE > $TARGET')
env = Environment(BUILDERS = {'Foo' : bld})
```

With the Builder so attached to our construction environment we can now actually call it like so:

```python
env.Foo('file.foo', 'file.input')
```

Then when we run SCons it looks like:

```
% scons -Q
foobuild < file.input > file.foo
```
Note, however, that the default $BUILDERS variable in a construction environment comes with a default set of Builder objects already defined: Program, Library, etc. And when we explicitly set the $BUILDERS variable when we create the construction environment, the default Builders are no longer part of the environment:

```python
bld = Builder(action = 'foobuild < $SOURCE > $TARGET')
env = Environment(BUILDERS = {'Foo' : bld})
env.Foo('file.foo', 'file.input')
env.Program('hello.c')
```

```
% scons -Q
AttributeError: SConsEnvironment instance has no attribute 'Program':
   File "~/home/my/project/SConstruct", line 4:
     env.Program('hello.c')
```

To be able to use both our own defined Builder objects and the default Builder objects in the same construction environment, you can either add to the $BUILDERS variable using the Append function:

```python
env = Environment()
bld = Builder(action = 'foobuild < $SOURCE > $TARGET')
env.Append(BUILDERS = {'Foo' : bld})
env.Foo('file.foo', 'file.input')
env.Program('hello.c')
```

Or you can explicitly set the appropriately-named key in the $BUILDERS dictionary:

```python
env = Environment()
bld = Builder(action = 'foobuild < $SOURCE > $TARGET')
env['BUILDERS']['Foo'] = bld
env.Foo('file.foo', 'file.input')
env.Program('hello.c')
```

Either way, the same construction environment can then use both the newly-defined Foo Builder and the default Program Builder:

```
% scons -Q
foobuild < file.input > file.foo
cc -o hello.o -c hello.c
cc -o hello hello.o
```
19.3. Letting SCons Handle The File Suffixes

By supplying additional information when you create a Builder, you can let SCons add appropriate file suffixes to the target and/or the source file. For example, rather than having to specify explicitly that you want the Foo Builder to build the file.foo target file from the file.input source file, you can give the .foo and .input suffixes to the Builder, making for more compact and readable calls to the Foo Builder:

```python
bld = Builder(action = 'foobuild < $SOURCE > $TARGET',
              suffix = '.foo',
              src_suffix = '.input')
env = Environment(BUILDERS = {'Foo' : bld})
env.Foo('file1')
env.Foo('file2')
```

You can also supply a prefix keyword argument if it's appropriate to have SCons append a prefix to the beginning of target file names.

19.4. Builders That Execute Python Functions

In SCons, you don’t have to call an external command to build a file. You can, instead, define a Python function that a Builder object can invoke to build your target file (or files). Such a builder function definition looks like:

```python
def build_function(target, source, env):
    # Code to build "target" from "source"
    return None
```

The arguments of a builder function are:

- **target**
  A list of Node objects representing the target or targets to be built by this builder function. The file names of these target(s) may be extracted using the Python `str` function.

- **source**
  A list of Node objects representing the sources to be used by this builder function to build the targets. The file names of these source(s) may be extracted using the Python `str` function.
The construction environment used for building the target(s). The builder function may use any of the environment’s construction variables in any way to affect how it builds the targets.

The builder function must return a 0 or None value if the target(s) are built successfully. The builder function may raise an exception or return any non-zero value to indicate that the build is unsuccessful.

Once you’ve defined the Python function that will build your target file, defining a Builder object for it is as simple as specifying the name of the function, instead of an external command, as the Builder’s action argument:

```python
def build_function(target, source, env):
    # Code to build "target" from "source"
    return None
bld = Builder(action = build_function,
    suffix = '.foo',
    src_suffix = '.input')
env = Environment(BUILDERS = {'Foo' : bld})
env.Foo('file')
```

And notice that the output changes slightly, reflecting the fact that a Python function, not an external command, is now called to build the target file:

```
% scons -Q
build_function(["file.foo"], ["file.input"])
```

## 19.5. Builders That Create Actions Using a Generator

SCons Builder objects can create an action "on the fly" by using a function called a generator. This provides a great deal of flexibility to construct just the right list of commands to build your target. A generator looks like:

```python
def generate_actions(source, target, env, for_signature):
    return 'foobuild < %s > %s' % (target[0], source[0])
```

The arguments of a generator are:

### source

A list of Node objects representing the sources to be built by the command or other action generated by this function. The file names of these source(s) may be extracted using the Python `str` function.
Chapter 19. Writing Your Own Builders

target

A list of Node objects representing the target or targets to be built by the command or other action generated by this function. The file names of these target(s) may be extracted using the Python `str` function.

env

The construction environment used for building the target(s). The generator may use any of the environment’s construction variables in any way to determine what command or other action to return.

for_signature

A flag that specifies whether the generator is being called to contribute to a build signature, as opposed to actually executing the command.

The generator must return a command string or other action that will be used to build the specified target(s) from the specified source(s).

Once you’ve defined a generator, you create a Builder to use it by specifying the generator keyword argument instead of action.

```python
def generate_actions(source, target, env, for_signature):
    return 'foobuild < %s > %s' % (source[0], target[0])
bld = Builder(generator = generate_actions,
                suffix = '.foo',
                src_suffix = '.input')
env = Environment(BUILDERS = {'Foo' : bld})
env.Foo('file')
```

Note that it’s illegal to specify both an action and a generator for a Builder.

19.6. Builders That Modify the Target or Source Lists Using an Emitter

SCons supports the ability for a Builder to modify the lists of target(s) from the specified source(s). You do this by defining an emitter function that takes as its arguments the list of the targets passed to the builder, the list of the sources passed to the builder, and the construction environment. The emitter function should return the modified lists of targets that should be built and sources from which the targets will be built.
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For example, suppose you want to define a Builder that always calls a foobuild program, and you want to automatically add a new target file named `new_target` and a new source file named `new_source` whenever it’s called. The `SConstruct` file might look like this:

```python
def modify_targets(target, source, env):
    target.append('new_target')
    source.append('new_source')
    return target, source

bld = Builder(action = 'foobuild $TARGETS - $SOURCES',
               suffix = '.foo',
               src_suffix = '.input',
               emitter = modify_targets)
env = Environment(BUILDERS = {'Foo' : bld})
env.Foo('file')
```

And would yield the following output:

```
% scons -Q
foobuild file.foo new_target - file.input new_source
```

One very flexible thing that you can is specify use a construction variable to specify different emitter functions for different construction variable. To do this, specify a string containing a construction variable expansion as the emitter when you call the `Builder` function, and set that construction variable to the desired emitter function in different construction environments:

```python
bld = Builder(action = 'my_command $SOURCES > $TARGET',
               suffix = '.foo',
               src_suffix = '.input',
               emitter = '$MY_EMITTER')
def modify1(target, source, env):
    return target, source + ['modify1.in']
def modify2(target, source, env):
    return target, source + ['modify2.in']
env1 = Environment(BUILDERS = {'Foo' : bld},
                   MY_EMITTER = modify1)
env2 = Environment(BUILDERS = {'Foo' : bld},
                   MY_EMITTER = modify2)
env1.Foo('file1')
env2.Foo('file2')
import os
env1['ENV'][PATH] = env2['ENV'][PATH] + os.pathsep + os.getcwd()  
env2['ENV'][PATH] = env2['ENV'][PATH] + os.pathsep + os.getcwd()
```
emitter = ‘$MY_EMITTER’
def modify1(target, source, env):
    return target, source + [‘modify1.in’]
def modify2(target, source, env):
    return target, source + [‘modify2.in’]
env1 = Environment(BUILDERS = {‘Foo’ : bld},
                   MY_EMITTER = modify1)
env2 = Environment(BUILDERS = {‘Foo’ : bld},
                   MY_EMITTER = modify2)
env1.Foo(‘file1’)
env2.Foo(‘file2’)

In this example, the modify1.in and modify2.in files get added to the source lists of the different commands:

% scons -Q
  my_command file1.input modify1.in > file1.foo
  my_command file2.input modify2.in > file2.foo

19.7. Where To Put Your Custom Builders and Tools

The site_scons directory gives you a place to put Python modules you can import into your SConscripts (site_scons), add-on tools that can integrate into SCons (site_scons/site_tools), and a site_scons/site_init.py file that gets read before any SConstruct or SConscript, allowing you to change SCons’s default behavior.

If you get a tool from somewhere (the SCons wiki or a third party, for instance) and you’d like to use it in your project, the site_scons dir is the simplest place to put it. Tools come in two flavors; either a Python function that operates on an Environment or a Python file containing two functions, exists() and generate().

A single-function Tool can just be included in your site_scons/site_init.py file where it will be parsed and made available for use. For instance, you could have a site_scons/site_init.py file like this:

    def TOOL_ADD_HEADER(env):
        """A Tool to add a header from $HEADER to the source file""
        add_header = Builder(action=[‘echo "$HEADER" > $TARGET’,
                                     ‘cat $SOURCE >> $TARGET’])
        env.Append(BUILDERS = {‘AddHeader’ : add_header})
        env[‘HEADER’] = ” # set default value
and a SConstruct like this:

```python
# Use TOOL_ADD_HEADER from site_scons/site_init.py
env=Environment(tools=['default', TOOL_ADD_HEADER], HEADER="=====")
env.AddHeader('tgt', 'src')
```

The TOOL_ADD_HEADER tool method will be called to add the AddHeader tool to the environment.

Similarly, a more full-fledged tool with exists() and generate() methods can be installed in site_scons/site_tools/toolname.py. Since site_scons/site_tools is automatically added to the head of the tool search path, any tool found there will be available to all environments. Furthermore, a tool found there will override a built-in tool of the same name, so if you need to change the behavior of a built-in tool, site_scons gives you the hook you need.

Many people have a library of utility Python functions they’d like to include in SConscript; just put that module in site_scons/my_utils.py or any valid Python module name of your choice. For instance you can do something like this in site_scons/my_utils.py to add a build_id method:

```python
def build_id():
    """Return a build ID (stub version)""
    return "100"
```

And then in your SConscript or any sub-SConscript anywhere in your build, you can import my_utils and use it:

```python
import my_utils
print "build_id=" + my_utils.build_id()
```

If you have a machine-wide site dir you’d like to use instead of ./site_scons, use the --site-dir option to point to your dir. site_init.py and site_tools will be located under that dir. To avoid using a site_scons dir at all, even if it exists, use the --no-site-dir option.
Chapter 20. Not Writing a Builder: the Command Builder

Creating a Builder and attaching it to a construction environment allows for a lot of flexibility when you want to re-use actions to build multiple files of the same type. This can, however, be cumbersome if you only need to execute one specific command to build a single file (or group of files). For these situations, SCons supports a Command Builder that arranges for a specific action to be executed to build a specific file or files. This looks a lot like the other builders (like Program, Object, etc.), but takes as an additional argument the command to be executed to build the file:

```python
env = Environment()
env.Command('foo.out', 'foo.in', "sed 's/x/y/' < $SOURCE > $TARGET")
```

When executed, SCons runs the specified command, substituting $SOURCE and $TARGET as expected:

```bash
% scons -Q
sed 's/x/y/' < foo.in > foo.out
```

This is often more convenient than creating a Builder object and adding it to the $BUILDERS variable of a construction environment.

Note that the action you specify to the Command Builder can be any legal SCons Action, such as a Python function:

```python
env = Environment()
def build(target, source, env):
    # Whatever it takes to build
    return None
env.Command('foo.out', 'foo.in', build)
```

Which executes as follows:

```bash
% scons -Q
build(["foo.out"], ["foo.in"])
```

Note that $SOURCE and $TARGET are expanded in the source and target as well as of SCons 1.1, so you can write:

```python
env.Command('${SOURCE.basename}.out', 'foo.in', build)
```
which does the same thing as the previous example, but allows you to avoid repeating yourself.
Chapter 21. Pseudo-Builders: the AddMethod function

The AddMethod function is used to add a method to an environment. It's typically used to add a "pseudo-builder," a function that looks like a Builder but wraps up calls to multiple other Builders or otherwise processes its arguments before calling one or more Builders. In the following example, we want to install the program into the standard /usr/bin directory hierarchy, but also copy it into a local install/bin directory from which a package might be built:

```
def install_in_bin_dirs(env, source):
    """Install source in both bin dirs""
    i1 = env.Install("$BIN", source)
    i2 = env.Install("$LOCALBIN", source)
    return [i1[0], i2[0]]  # Return a list, like a normal builder
env = Environment(BIN="/usr/bin", LOCALBIN="#install/bin")
env.AddMethod(install_in_bin_dirs, "InstallInBinDirs")
env.InstallInBinDirs(Program('hello.c'))  # installs hello in both bin dirs
```

This produces the following:

```
% scons -Q /
cc -o hello.o -c hello.c
cc -o hello hello.o
Install file: "hello" as "/usr/bin/hello"
Install file: "hello" as "install/bin/hello"
```

As mentioned, a psuedo-builder also provides more flexibility in parsing arguments than you can get with a Builder. The next example shows a pseudo-builder with a named argument that modifies the filename, and a separate argument for the resource file (rather than having the builder figure it out by file extension). This example also demonstrates using the global AddMethod function to add a method to the global Environment class, so it will be used in all subsequently created environments.

```
def BuildTestProg(env, testfile, resourcefile, testdir="tests"):
    """Build the test program;
    prepends "test_" to src and target,
    and puts target into testdir.""
    srcfile = "test_\$s.c" % testfile
    target = "\$s/test_\$s" % (testdir, testfile)
    if env["PLATFORM"] == 'win32':
        resfile = env.RES(resourcefile)
        p = env.Program(target, [srcfile, resfile])
    else:
        p = env.Program(target, srcfile)
    return p
AddMethod(Environment, BuildTestProg)
```
env = Environment()
env.BuildTestProg('stuff', resourcefile='res.rc')

This produces the following on Linux:

```bash
% scons -Q
c -o test_stuff.o -c test_stuff.c
c -o tests/test_stuff test_stuff.o
```

And the following on Windows:

```bash
C:\>scons -Q
rc /fores.res res.rc
c /Fotest_stuff.obj /c test_stuff.c /nologo
link /nologo /OUT:tests\test_stuff.exe test_stuff.obj res.res
```

Using AddMethod is better than just adding an instance method to a construction environment because it gets called as a proper method, and because AddMethod provides for copying the method to any clones of the construction environment instance.
Chapter 22. Writing Scanners

SCons has built-in scanners that know how to look in C, Fortran and IDL source files for information about other files that targets built from those files depend on—for example, in the case of files that use the C preprocessor, the .h files that are specified using \#include lines in the source. You can use the same mechanisms that SCons uses to create its built-in scanners to write scanners of your own for file types that SCons does not know how to scan "out of the box."

22.1. A Simple Scanner Example

Suppose, for example, that we want to create a simple scanner for .foo files. A .foo file contains some text that will be processed, and can include other files on lines that begin with include followed by a file name:

```
include filename.foo
```

Scanning a file will be handled by a Python function that you must supply. Here is a function that will use the Python re module to scan for the include lines in our example:

```
import re

include_re = re.compile(r'^include\s+(\S+)$', re.M)

def kfile_scan(node, env, path, arg):
    contents = node.get_contents()
    return include_re.findall(contents)
```

The scanner function must accept the four specified arguments and return a list of implicit dependencies. Presumably, these would be dependencies found from examining the contents of the file, although the function can perform any manipulation at all to generate the list of dependencies.

node

An SCons node object representing the file being scanned. The path name to the file can be used by converting the node to a string using the str() function, or an internal SCons get_contents() object method can be used to fetch the contents.

e

The construction environment in effect for this scan. The scanner function may choose to use construction variables from this environment to affect its behavior.
Chapter 22. Writing Scanners

path
A list of directories that form the search path for included files for this scanner. This is how SCons handles the $CPPPATH and $LIBPATH variables.

arg
An optional argument that you can choose to have passed to this scanner function by various scanner instances.

A Scanner object is created using the Scanner function, which typically takes an skeys argument to associate the type of file suffix with this scanner. The Scanner object must then be associated with the $SCANNERS construction variable of a construction environment, typically by using the Append method:

```python
kscan = Scanner(function = kfile_scan,
                 skeys = ['.k'])
env.Append(SCANNERS = kscan)
```

When we put it all together, it looks like:

```python
import re
include_re = re.compile(r'^include\s+(\S+)$', re.M)
def kfile_scan(node, env, path):
    contents = node.get_contents()
    includes = include_re.findall(contents)
    return includes

kscan = Scanner(function = kfile_scan,
                 skeys = ['.k'])
env = Environment(ENV = {'PATH' : '/usr/local/bin'})
env.Append(SCANNERS = kscan)
env.Command('foo', 'foo.k', 'kprocess < $SOURCES > $TARGET')
```
Chapter 23. Building From Code Repositories

Often, a software project will have one or more central repositories, directory trees that contain source code, or derived files, or both. You can eliminate additional unnecessary rebuilds of files by having SCons use files from one or more code repositories to build files in your local build tree.

23.1. The Repository Method

It’s often useful to allow multiple programmers working on a project to build software from source files and/or derived files that are stored in a centrally-accessible repository, a directory copy of the source code tree. (Note that this is not the sort of repository maintained by a source code management system like BitKeeper, CVS, or Subversion.) You use the Repository method to tell SCons to search one or more central code repositories (in order) for any source files and derived files that are not present in the local build tree:

```python
env = Environment()
env.Program('hello.c')
Repository('/usr/repository1', '/usr/repository2')
```

Multiple calls to the Repository method will simply add repositories to the global list that SCons maintains, with the exception that SCons will automatically eliminate the current directory and any non-existent directories from the list.

23.2. Finding source files in repositories

The above example specifies that SCons will first search for files under the /usr/repository1 tree and next under the /usr/repository2 tree. SCons expects that any files it searches for will be found in the same position relative to the top-level directory. In the above example, if the hello.c file is not found in the local build tree, SCons will search first for a /usr/repository1/hello.c file and then for a /usr/repository2/hello.c file to use in its place.

So given the SConstruct file above, if the hello.c file exists in the local build directory, SCons will rebuild the hello program as normal:

```bash
% scons -Q
  cc -o hello.o -c hello.c
  cc -o hello hello.o
```

If, however, there is no local hello.c file, but one exists in /usr/repository1, SCons will recompile the hello program from the source file it finds in the repository:
Chapter 23. Building From Code Repositories

\% scons -Q
cc -o hello.o -c /usr/repository1/hello.c
cc -o hello hello.o

And similarly, if there is no local hello.c file and no /usr/repository1/hello.c, but one exists in /usr/repository2:

\% scons -Q
cc -o hello.o -c /usr/repository2/hello.c
cc -o hello hello.o

23.3. Finding \#include files in repositories

We’ve already seen that SCons will scan the contents of a source file for \#include file names and realize that targets built from that source file also depend on the \#include file(s). For each directory in the $CPPPATH list, SCons will actually search the corresponding directories in any repository trees and establish the correct dependencies on any \#include files that it finds in repository directory.

Unless the C compiler also knows about these directories in the repository trees, though, it will be unable to find the \#include files. If, for example, the hello.c file in our previous example includes the hello.h; in its current directory, and the hello.h; only exists in the repository:

\% scons -Q
cc -o hello.o -c hello.c
hello.c:1: hello.h: No such file or directory

In order to inform the C compiler about the repositories, SCons will add appropriate -I flags to the compilation commands for each directory in the $CPPPATH list. So if we add the current directory to the construction environment $CPPPATH like so:

```
env = Environment(CPPPATH = [’.’])
env.Program(’hello.c’)
Repository(’/usr/repository1’)
```

Then re-executing SCons yields:

\% scons -Q
cc -o hello.o -c -I -I/usr/repository1 hello.c
cc -o hello hello.o
The order of the `–I` options replicates, for the C preprocessor, the same repository-directory search path that SCons uses for its own dependency analysis. If there are multiple repositories and multiple SCPATH directories, SCons will add the repository directories to the beginning of each SCPATH directory, rapidly multiplying the number of `–I` flags. If, for example, the SCPATH contains three directories (and shorter repository path names!):

```python
env = Environment(CPPPATH = ['dir1', 'dir2', 'dir3'])
env.Program('hello.c')
Repository('/r1', '/r2')
```

Then we’ll end up with nine `–I` options on the command line, three (for each of the SCPATH directories) times three (for the local directory plus the two repositories):

```bash
% scons -Q
cc -o hello.o -c -Idir1 -I/r1/dir1 -I/r2/dir1 -Idir2 -I/r1/dir2 -I/r2/dir2 -Idir3 -I/r1/dir3 -I/r2/dir3 hello.c
cc -o hello hello.o
```

### 23.3.1. Limitations on `#include` files in repositories

SCons relies on the C compiler’s `–I` options to control the order in which the preprocessor will search the repository directories for `#include` files. This causes a problem, however, with how the C preprocessor handles `#include` lines with the file name included in double-quotes.

As we’ve seen, SCons will compile the `hello.c` file from the repository if it doesn’t exist in the local directory. If, however, the `hello.c` file in the repository contains a `#include` line with the file name in double quotes:

```c
#include "hello.h"
int
main(int argc, char *argv[])
{
    printf(HELLO_MESSAGE);
    return (0);
}
```

Then the C preprocessor will always use a `hello.h` file from the repository directory first, even if there is a `hello.h` file in the local directory, despite the fact that the command line specifies `–I` as the first option:

```bash
% scons -Q
cc -o hello.o -c -I. -I/usr/repository1 /usr/repository1/hello.c
cc -o hello hello.o
```
Chapter 23. Building From Code Repositories

This behavior of the C preprocessor--always search for a #include file in double-quotes first in the same directory as the source file, and only then search the -I--can not, in general, be changed. In other words, it's a limitation that must be lived with if you want to use code repositories in this way. There are three ways you can possibly work around this C preprocessor behavior:

1. Some modern versions of C compilers do have an option to disable or control this behavior. If so, add that option to $CFLAGS (or $CXXFLAGS or both) in your construction environment(s). Make sure the option is used for all construction environments that use C preprocessing!

2. Change all occurrences of #include "file.h" to #include <file.h>. Use of #include with angle brackets does not have the same behavior--the -I directories are searched first for #include files--which gives SCons direct control over the list of directories the C preprocessor will search.

3. Require that everyone working with compilation from repositories check out and work on entire directories of files, not individual files. (If you use local wrapper scripts around your source code control system’s command, you could add logic to enforce this restriction there.

23.4. Finding the SConstruct file in repositories

SCons will also search in repositories for the SConstruct file and any specified SConscript files. This poses a problem, though: how can SCons search a repository tree for an SConstruct file if the SConstruct file itself contains the information about the pathname of the repository? To solve this problem, SCons allows you to specify repository directories on the command line using the -Y option:

```
% scons -Q -Y /usr/repository1 -Y /usr/repository2
```

When looking for source or derived files, SCons will first search the repositories specified on the command line, and then search the repositories specified in the SConstruct or SConscript files.

23.5. Finding derived files in repositories

If a repository contains not only source files, but also derived files (such as object files, libraries, or executables), SCons will perform its normal MD5 signature calculation to decide if a derived file in a repository is up-to-date, or the derived file must be rebuilt in the local build directory. For the SCons signature calculation to work correctly, a repository tree must contain the .sconsign files that SCons uses to keep track of signature information.

Usually, this would be done by a build integrator who would run SCons in the repository to create all of its derived files and .sconsign files, or who would run SCons in a separate build directory and copy the resulting tree to the desired repository:

```
% cd /usr/repository1
% scons -Q
```
Chapter 23. Building From Code Repositories

cc -o file1.o -c file1.c
cc -o file2.o -c file2.c
cc -o hello.o -c hello.c
cc -o hello hello.o file1.o file2.o

(Note that this is safe even if the SConstruct file lists /usr/repository1 as a repository, because SCons will remove the current build directory from its repository list for that invocation.)

Now, with the repository populated, we only need to create the one local source file we’re interested in working with at the moment, and use the -Y option to tell SCons to fetch any other files it needs from the repository:

% cd $HOME/build
% edit hello.c
% scons -Q -Y /usr/repository1
cc -c -o hello.o hello.c
cc -o hello hello.o /usr/repository1/file1.o /usr/repository1/file2.o

Notice that SCons realizes that it does not need to rebuild local copies file1.o and file2.o files, but instead uses the already-compiled files from the repository.

23.6. Guaranteeing local copies of files

If the repository tree contains the complete results of a build, and we try to build from the repository without any files in our local tree, something moderately surprising happens:

% mkdir $HOME/build2
% cd $HOME/build2
% scons -Q -Y /usr/all/repository hello
scons: ‘hello’ is up-to-date.

Why does SCons say that the hello program is up-to-date when there is no hello program in the local build directory? Because the repository (not the local directory) contains the up-to-date hello program, and SCons correctly determines that nothing needs to be done to rebuild that up-to-date copy of the file.

There are, however, many times when you want to ensure that a local copy of a file always exists. A packaging or testing script, for example, may assume that certain generated files exist locally. To tell SCons to make a copy of any up-to-date repository file in the local build directory, use the Local function:

```python
env = Environment()
hello = env.Program(‘hello.c’)```
If we then run the same command, SCons will make a local copy of the program from the repository copy, and tell you that it is doing so:

```
% scons -Y /usr/all/repository hello
Local copy of hello from /usr/all/repository/hello
scons: `hello’ is up-to-date.
```

(Notice that, because the act of making the local copy is not considered a "build" of the hello file, SCons still reports that it is up-to-date.)
Chapter 24. Multi-Platform Configuration (Autoconf Functionality)

SCons has integrated support for multi-platform build configuration similar to that offered by GNU Autoconf, such as figuring out what libraries or header files are available on the local system. This section describes how to use this SCons feature.

Note: This chapter is still under development, so not everything is explained as well as it should be. See the SCons man page for additional information.

24.1. Configure Contexts

The basic framework for multi-platform build configuration in SCons is to attach a configure context to a construction environment by calling the Configure function, perform a number of checks for libraries, functions, header files, etc., and to then call the configure context’s Finish method to finish off the configuration:

```python
env = Environment()
conf = Configure(env)
# Checks for libraries, header files, etc. go here!
env = conf.Finish()
```

SCons provides a number of basic checks, as well as a mechanism for adding your own custom checks.

Note that SCons uses its own dependency mechanism to determine when a check needs to be run--that is, SCons does not run the checks every time it is invoked, but caches the values returned by previous checks and uses the cached values unless something has changed. This saves a tremendous amount of developer time while working on cross-platform build issues.

The next sections describe the basic checks that SCons supports, as well as how to add your own custom checks.

24.2. Checking for the Existence of Header Files

Testing the existence of a header file requires knowing what language the header file is. A configure context has a CheckCHeader method that checks for the existence of a C header file:

```python
env = Environment()
```
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conf = Configure(env)
if not conf.CheckCHeader('math.h'):
    print 'Math.h must be installed!'
    Exit(1)
if conf.CheckCHeader('foo.h'):
    conf.env.Append('-DHAS_FOO_H')
env = conf.Finish()

Note that you can choose to terminate the build if a given header file doesn’t exist, or you can modify the construction environment based on the existence of a header file.

If you need to check for the existence a C++ header file, use the CheckCXXHeader method:

env = Environment()
conf = Configure(env)
if not conf.CheckCXXHeader('vector.h'):
    print 'vector.h must be installed!'
    Exit(1)
env = conf.Finish()

24.3. Checking for the Availability of a Function

Check for the availability of a specific function using the CheckFunc method:

env = Environment()
conf = Configure(env)
if not conf.CheckFunc('strcpy'):
    print 'Did not find strcpy(), using local version'
    conf.env.Append(CPPDEFINES = '-Dstrcpy=my_local_strcpy')
env = conf.Finish()

24.4. Checking for the Availability of a Library

Check for the availability of a library using the CheckLib method. You only specify the basename of the library, you don’t need to add a lib prefix or a .a or .lib suffix:

env = Environment()
conf = Configure(env)
if not conf.CheckLib('m'):
    print 'Did not find libm.a or m.lib, exiting!'
    Exit(1)
Because the ability to use a library successfully often depends on having access to a header file that describes the library’s interface, you can check for a library and a header file at the same time by using the CheckLibWithHeader method:

```
env = Environment()
conf = Configure(env)
if not conf.CheckLibWithHeader('m', 'math.h', 'c'):
    print 'Did not find libm.a or m.lib, exiting!'  
    Exit(1)
env = conf.Finish()
```

This is essentially shorthand for separate calls to the CheckHeader and CheckLib functions.

### 24.5. Checking for the Availability of a `typedef`

Check for the availability of a `typedef` by using the CheckType method:

```
env = Environment()
conf = Configure(env)
if not conf.CheckType('off_t'):
    print 'Did not find off_t typedef, assuming int'
    conf.env.Append(CCFLAGS = '-Doff_t=int')
env = conf.Finish()
```

You can also add a string that will be placed at the beginning of the test file that will be used to check for the `typedef`. This provide a way to specify files that must be included to find the `typedef`:

```
env = Environment()
conf = Configure(env)
if not conf.CheckType('off_t', '#include <sys/types.h>
'):  
    print 'Did not find off_t typedef, assuming int'
    conf.env.Append(CCFLAGS = '-Doff_t=int')
env = conf.Finish()
```

### 24.6. Adding Your Own Custom Checks

A custom check is a Python function that checks for a certain condition to exist on the running system, usually using methods that SCons supplies to take care of the details of checking whether a compilation
succeeds, a link succeeds, a program is runnable, etc. A simple custom check for the existence of a specific library might look as follows:

```python
mylib_test_source_file = """
#include <mylib.h>
int main(int argc, char **argv)
{
    MyLibrary mylib(argc, argv);
    return 0;
}
"""

def CheckMyLibrary(context):
    context.Message('Checking for MyLibrary...')
    result = context.TryLink(mylib_test_source_file, '.c')
    context.Result(result)
    return result
```

The `Message` and `Result` methods should typically begin and end a custom check to let the user know what’s going on: the `Message` call prints the specified message (with no trailing newline) and the `Result` call prints `ok` if the check succeeds and `failed` if it doesn’t. The `TryLink` method actually tests for whether the specified program text will successfully link.

(Nota that a custom check can modify its check based on any arguments you choose to pass it, or by using or modifying the configure context environment in the `context.env` attribute.)

This custom check function is then attached to the configure context by passing a dictionary to the `Configure` call that maps a name of the check to the underlying function:

```python
env = Environment()
conf = Configure(env, custom_tests = {'CheckMyLibrary' : CheckMyLibrary})
```

You’ll typically want to make the check and the function name the same, as we’ve done here, to avoid potential confusion.

We can then put these pieces together and actually call the `CheckMyLibrary` check as follows:

```python
mylib_test_source_file = """
#include <mylib.h>
int main(int argc, char **argv)
{
    MyLibrary mylib(argc, argv);
    return 0;
}
"""

def CheckMyLibrary(context):
```
context.Message('Checking for MyLibrary... ’)
result = context.TryLink(mylib_test_source_file, ’.c’)
context.Result(result)
return result

env = Environment()
conf = Configure(env, custom_tests = {‘CheckMyLibrary’ : CheckMyLibrary})
if not conf.CheckMyLibrary():
    print 'MyLibrary is not installed!'
Exit(1)
env = conf.Finish()

# We would then add actual calls like Program() to build
# something using the "env" construction environment.

If MyLibrary is not installed on the system, the output will look like:

% scons
scons: Reading SConscript file ...
Checking for MyLibrary... failed
MyLibrary is not installed!

If MyLibrary is installed, the output will look like:

% scons
scons: Reading SConscript file ...
Checking for MyLibrary... failed
scons: done reading SConscript
scons: Building targets ...
.
.
.

24.7. Not Configuring When Cleaning Targets

Using multi-platform configuration as described in the previous sections will run the configuration commands even when invoking scons -c to clean targets:

% scons -Q -c
Checking for MyLibrary... ok
Removed foo.o
Removed foo
Although running the platform checks when removing targets doesn’t hurt anything, it’s usually unnecessary. You can avoid this by using the GetOption(); method to check whether the \texttt{-c} (clean) option has been invoked on the command line:

```python
env = Environment()
if not env.GetOption('clean'):
    conf = Configure(env, custom_tests = {'CheckMyLibrary' : CheckMyLibrary})
    if not conf.CheckMyLibrary():
        print 'MyLibrary is not installed!'
        Exit(1)
    env = conf.Finish()
```

```
% scons -Q -c
Removed foo.o
Removed foo
```
Chapter 25. Caching Built Files

On multi-developer software projects, you can sometimes speed up every developer’s builds a lot by allowing them to share the derived files that they build. SCons makes this easy, as well as reliable.

25.1. Specifying the Shared Cache Directory

To enable sharing of derived files, use the CacheDir function in any SConscript file:

```
CacheDir('/usr/local/build_cache')
```

Note that the directory you specify must already exist and be readable and writable by all developers who will be sharing derived files. It should also be in some central location that all builds will be able to access. In environments where developers are using separate systems (like individual workstations) for builds, this directory would typically be on a shared or NFS-mounted file system.

Here’s what happens: When a build has a CacheDir specified, every time a file is built, it is stored in the shared cache directory along with its MD5 build signature. 1 On subsequent builds, before an action is invoked to build a file, SCons will check the shared cache directory to see if a file with the exact same build signature already exists. If so, the derived file will not be built locally, but will be copied into the local build directory from the shared cache directory, like so:

```
% scons -Q
cc -o hello.o -c hello.c
cc -o hello hello.o
% scons -Q -c
Removed hello.o
Removed hello
% scons -Q
Retrieved ‘hello.o’ from cache
Retrieved ‘hello’ from cache
```

Note that the CacheDir feature still calculates MD5 build signatures for the shared cache file names even if you configure SCons to use timestamps to decide if files are up to date. (See the Chapter 6 chapter for information about the Decider function.) Consequently, using CacheDir may reduce or eliminate any potential performance improvements from using timestamps for up-to-date decisions.
25.2. Keeping Build Output Consistent

One potential drawback to using a shared cache is that the output printed by SCons can be inconsistent from invocation to invocation, because any given file may be rebuilt one time and retrieved from the shared cache the next time. This can make analyzing build output more difficult, especially for automated scripts that expect consistent output each time.

If, however, you use the `--cache-show` option, SCons will print the command line that it would have executed to build the file, even when it is retrieving the file from the shared cache. This makes the build output consistent every time the build is run:

```
% scons -Q
 cc -o hello.o -c hello.c
 cc -o hello hello.o
 % scons -Q -c
 Removed hello.o
 Removed hello
 % scons -Q --cache-show
 cc -o hello.o -c hello.c
 cc -o hello hello.o
```

The trade-off, of course, is that you no longer know whether or not SCons has retrieved a derived file from cache or has rebuilt it locally.

25.3. Not Using the Shared Cache for Specific Files

You may want to disable caching for certain specific files in your configuration. For example, if you only want to put executable files in a central cache, but not the intermediate object files, you can use the `NoCache` function to specify that the object files should not be cached:

```
env = Environment()
obj = env.Object('hello.c')
env.Program('hello.c')
CacheDir('cache')
NoCache('hello.o')
```

Then when you run scons after cleaning the built targets, it will recompile the object file locally (since it doesn’t exist in the shared cache directory), but still realize that the shared cache directory contains an up-to-date executable program that can be retrieved instead of re-linking:

```
  % scons -Q
  cc -o hello.o -c hello.c
  cc -o hello hello.o
  % scons -Q -c
```
25.4. Disabling the Shared Cache

Retrieving an already-built file from the shared cache is usually a significant time-savings over rebuilding the file, but how much of a savings (or even whether it saves time at all) can depend a great deal on your system or network configuration. For example, retrieving cached files from a busy server over a busy network might end up being slower than rebuilding the files locally.

In these cases, you can specify the \texttt{--cache-disable} command-line option to tell SCons to not retrieve already-built files from the shared cache directory:

\begin{verbatim}
% scons -Q
cc -o hello.o -c hello.c
cc -o hello hello.o
% scons -Q --cache-disable
cc -o hello.o -c hello.c
cc -o hello hello.o
\end{verbatim}

25.5. Populating a Shared Cache With Already-Built Files

Sometimes, you may have one or more derived files already built in your local build tree that you wish to make available to other people doing builds. For example, you may find it more effective to perform integration builds with the cache disabled (per the previous section) and only populate the shared cache directory with the built files after the integration build has completed successfully. This way, the cache will only get filled up with derived files that are part of a complete, successful build not with files that might be later overwritten while you debug integration problems.
In this case, you can use the the `--cache-force` option to tell SCons to put all derived files in the cache, even if the files already exist in your local tree from having been built by a previous invocation:

```bash
% scons -Q --cache-disable
cc -o hello.o -c hello.c
cc -o hello hello.o
% scons -Q -c
Removed hello.o
Removed hello
% scons -Q --cache-disable
cc -o hello.o -c hello.c
cc -o hello hello.o
% scons -Q --cache-force
scons: '.' is up to date.
% scons -Q
scons: '.' is up to date.
```

Notice how the above sample run demonstrates that the `--cache-disable` option avoids putting the built `hello.o` and `hello` files in the cache, but after using the `--cache-force` option, the files have been put in the cache for the next invocation to retrieve.

### 25.6. Minimizing Cache Contention: the `--random` Option

If you allow multiple builds to update the shared cache directory simultaneously, two builds that occur at the same time can sometimes start "racing" with one another to build the same files in the same order. If, for example, you are linking multiple files into an executable program:

```python
Program('prog',
        ['f1.c', 'f2.c', 'f3.c', 'f4.c', 'f5.c'])
```

SCons will normally build the input object files on which the program depends in their normal, sorted order:

```bash
% scons -Q
cc -o f1.o -c f1.c
cc -o f2.o -c f2.c
cc -o f3.o -c f3.c
cc -o f4.o -c f4.c
cc -o f5.o -c f5.c
cc -o prog f1.o f2.o f3.o f4.o f5.o
```

But if two such builds take place simultaneously, they may each look in the cache at nearly the same time and both decide that `f1.o` must be rebuilt and pushed into the shared cache directory, then both decide that `f2.o` must be rebuilt (and pushed into the shared cache directory), then both decide that `f3.o` must
be rebuilt... This won’t cause any actual build problems—both builds will succeed, generate correct output files, and populate the cache—but it does represent wasted effort.

To alleviate such contention for the cache, you can use the `--random` command-line option to tell SCons to build dependencies in a random order:

```
% scons -Q --random
cc -o f3.o -c f3.c
cc -o f1.o -c f1.c
cc -o f5.o -c f5.c
cc -o f2.o -c f2.c
cc -o f4.o -c f4.c
cc -o prog f1.o f2.o f3.o f4.o f5.o
```

Multiple builds using the `--random` option will usually build their dependencies in different, random orders, which minimizes the chances for a lot of contention for same-named files in the shared cache directory. Multiple simultaneous builds might still race to try to build the same target file on occasion, but long sequences of inefficient contention should be rare.

Note, of course, the `--random` option will cause the output that SCons prints to be inconsistent from invocation to invocation, which may be an issue when trying to compare output from different build runs.

If you want to make sure dependencies will be built in a random order without having to specify the `--random` on very command line, you can use the `SetOption` function to set the `random` option within any `SConscript` file:

```
Program('prog',
    ['f1.c', 'f2.c', 'f3.c', 'f4.c', 'f5.c'])
SetOption('random', 1)
Program('prog',
    ['f1.c', 'f2.c', 'f3.c', 'f4.c', 'f5.c'])
```

### Notes

1. Actually, the MD5 signature is used as the name of the file in the shared cache directory in which the contents are stored.
Chapter 26. Alias Targets

We’ve already seen how you can use the Alias function to create a target named install:

```python
env = Environment()
hello = env.Program('hello.c')
env.Install('/usr/bin', hello)
env.Alias('install', '/usr/bin')
```

You can then use this alias on the command line to tell SCons more naturally that you want to install files:

```
% scons -Q install
cc -o hello.o -c hello.c
cc -o hello hello.o
Install file: "hello" as "/usr/bin/hello"
```

Like other Builder methods, though, the Alias method returns an object representing the alias being built. You can then use this object as input to another Builder. This is especially useful if you use such an object as input to another call to the Alias Builder, allowing you to create a hierarchy of nested aliases:

```python
env = Environment()
p = env.Program('foo.c')
l = env.Library('bar.c')
env.Install('/usr/bin', p)
env.Install('/usr/lib', l)
ib = env.Alias('install-bin', '/usr/bin')
il = env.Alias('install-lib', '/usr/lib')
env.Alias('install', [ib, il])
```

This example defines separate install, install-bin, and install-lib aliases, allowing you finer control over what gets installed:

```
% scons -Q install-bin
cc -o foo.o -c foo.c
cc -o foo foo.o
Install file: "foo" as "/usr/bin/foo"
% scons -Q install-lib
cc -o bar.o -c bar.c
ar rc libbar.a bar.o
ranlib libbar.a
Install file: "libbar.a" as "/usr/lib/libbar.a"
% scons -Q -c /
Removed foo.o
Removed foo
Removed /usr/bin/foo
```
Removed bar.o
Removed libbar.a
Removed /usr/lib/libbar.a

% scons -Q install
cc -o foo.o -c foo.c
cc -o foo foo.o
Install file: "foo" as "'/usr/bin/foo"
cc -o bar.o -c bar.c
ar rc libbar.a bar.o
ranlib libbar.a
Install file: "libbar.a" as "'/usr/lib/libbar.a"
Chapter 27. Java Builds

So far, we’ve been using examples of building C and C++ programs to demonstrate the features of SCons. SCons also supports building Java programs, but Java builds are handled slightly differently, which reflects the ways in which the Java compiler and tools build programs differently than other languages’ tool chains.

27.1. Building Java Class Files: the Java Builder

The basic activity when programming in Java, of course, is to take one or more .java files containing Java source code and to call the Java compiler to turn them into one or more .class files. In SCons, you do this by giving the Java Builder a target directory in which to put the .class files, and a source directory that contains the .java files:

```python
Java('classes', 'src')
```

If the src directory contains three .java source files, then running SCons might look like this:

```bash
% scons -Q javac -d classes -sourcepath src src/Example1.java src/Example2.java src/Example3.java
```

SCons will actually search the src directory tree for all of the .java files. The Java compiler will then create the necessary class files in the classes subdirectory, based on the class names found in the .java files.

27.2. How SCons Handles Java Dependencies

In addition to searching the source directory for .java files, SCons actually runs the .java files through a stripped-down Java parser that figures out what classes are defined. In other words, SCons knows, without you having to tell it, what .class files will be produced by the javac call. So our one-liner example from the preceding section:

```python
Java('classes', 'src')
```

Will not only tell you reliably that the .class files in the classes subdirectory are up-to-date:

```bash
% scons -Q javac -d classes -sourcepath src src/Example1.java src/Example2.java src/Example3.java
% scons -Q classes
scons: 'classes' is up to date.
```
But it will also remove all of the generated .class files, even for inner classes, without you having to specify them manually. For example, if our Example1.java and Example3.java files both define additional classes, and the class defined in Example2.java has an inner class, running `scons -c` will clean up all of those .class files as well:

```
% scons -Q
javac -d classes -sourcepath src src/Example1.java src/Example2.java src/Example3.java
% scons -Q -c classes
Removed classes/Example1.class
Removed classes/AdditionalClass1.class
Removed classes/Example2$Inner2.class
Removed classes/Example2.class
Removed classes/Example3.class
Removed classes/AdditionalClass3.class
```

### 27.3. Building Java Archive (.jar) Files: the Jar Builder

After building the class files, it’s common to collect them into a Java archive (.jar) file, which you do by calling the `Jar` Builder method. If you want to just collect all of the class files within a subdirectory, you can just specify that subdirectory as the `Jar` source:

```
Java(target = 'classes', source = 'src')
Jar(target = 'test.jar', source = 'classes')
```

SCons will then pass that directory to the jar command, which will collect all of the underlying .class files:

```
% scons -Q
javac -d classes -sourcepath src/src/Example1.java src/Example2.java src/Example3.java
jar cf test.jar classes
```

If you want to keep all of the .class files for multiple programs in one location, and only archive some of them in each .jar file, you can pass the `Jar` builder a list of files as its source. It’s extremely simple to create multiple .jar files this way, using the lists of target class files created by calls to the `Java` builder as sources to the various `Jar` calls:

```
progl_class_files = Java(target = 'classes', source = 'progl')
prog2_class_files = Java(target = 'classes', source = 'prog2')
Jar(target = 'progl.jar', source = progl_class_files)
Jar(target = 'prog2.jar', source = prog2_class_files)
```
This will then create `prog1.jar` and `prog2.jar` next to the subdirectories that contain their `.java` files:

```
% scons -Q
javac -d classes -sourcepath prog1 prog1/Example1.java prog1/Example2.java
javac -d classes -sourcepath prog2 prog2/Example3.java prog2/Example4.java
jar cf prog1.jar -C classes Example1.class -C classes Example2.class
jar cf prog2.jar -C classes Example3.class -C classes Example4.class
```

### 27.4. Building C Header and Stub Files: the `JavaH` Builder

You can generate C header and source files for implementing native methods, by using the `JavaH` Builder. There are several ways of using the `JavaH` Builder. One typical invocation might look like:

```python
classes = Java(target = 'classes', source = 'src/pkg/sub')
JavaH(target = 'native', source = classes)
```

The source is a list of class files generated by the call to the `Java` Builder, and the target is the output directory in which we want the C header files placed. The target gets converted into the `-d` when SCons runs javah:

```
% scons -Q
javac -d classes -sourcepath src/pkg/sub src/pkg/sub/Example1.java src/pkg/sub/Example2.java src/pkg/sub/Example3.java
javah -d native -classpath classes pkg.sub.Example1 pkg.sub.Example2 pkg.sub.Example3
```

In this case, the call to javah will generate the header files `native/pkg_sub_Example1.h`, `native/pkg_sub_Example2.h` and `native/pkg_sub_Example3.h`. Notice that SCons remembered that the class files were generated with a target directory of `classes`, and that it then specified that target directory as the `-classpath` option to the call to javah.

Although it’s more convenient to use the list of class files returned by the `Java` Builder as the source of a call to the `JavaH` Builder, you can specify the list of class files by hand, if you prefer. If you do, you need to set the `$JAVACLASSDIR` construction variable when calling `JavaH`:

```python
Java(target = 'classes', source = 'src/pkg/sub')
class_file_list = ['classes/pkg/sub/Example1.class',
                  'classes/pkg/sub/Example2.class',
                  'classes/pkg/sub/Example3.class']
JavaH(target = 'native', source = class_file_list, JAVACLASSDIR = 'classes')
```

The `$JAVACLASSDIR` value then gets converted into the `-classpath` when SCons runs javah:
Lastly, if you don’t want a separate header file generated for each source file, you can specify an explicit
File Node as the target of the JavaH Builder:

```python
classes = Java(target = 'classes', source = 'src/pkg/sub')
JavaH(target = File('native.h'), source = classes)
```

Because SCons assumes by default that the target of the JavaH builder is a directory, you need to use the
File function to make sure that SCons doesn’t create a directory named native.h. When a file is used, though, SCons correctly converts the file name into the javah -o option:

```bash
% scons -Q
javac -d classes -sourcepath src/pkg/sub src/pkg/sub/Example1.java src/pkg/sub/Example2.java src/pkg/sub/Example3.java
javah -o native.h -classpath classes pkg.sub.Example1 pkg.sub.Example2 pkg.sub.Example3
```

### 27.5. Building RMI Stub and Skeleton Class Files: the RMIC Builder

You can generate Remote Method Invocation stubs by using the RMIC Builder. The source is a list of
directories, typically returned by a call to the Java Builder, and the target is an output directory where
the _Stub.class and _Skel.class files will be placed:

```python
classes = Java(target = 'classes', source = 'src/pkg/sub')
RMIC(target = 'outdir', source = classes)
```

As it did with the JavaH Builder, SCons remembers the class directory and passes it as the -classpath
option to rmic:

```bash
% scons -Q
javac -d classes -sourcepath src/pkg/sub src/pkg/sub/Example1.java src/pkg/sub/Example2.java
rmic -d outdir -classpath classes pkg.sub.Example1 pkg.sub.Example2
```

This example would generate the files `outdir/pkg/sub/Example1_Skel.class`,
dir/pkg/sub/Example1_Stub.class, `outdir/pkg/sub/Example2_Skel.class`, `outdir/pkg/sub/Example2_Stub.class`. and
Chapter 28. Miscellaneous Functionality

SCons supports a lot of additional functionality that doesn’t readily fit into the other chapters.


Although the SCons code itself will run on any Python version 1.5.2 or later, you are perfectly free to make use of Python syntax and modules from more modern versions (for example, Python 2.4 or 2.5) when writing your SConscript files or your own local modules. If you do this, it’s usually helpful to configure SCons to exit gracefully with an error message if it’s being run with a version of Python that simply won’t work with your code. This is especially true if you’re going to use SCons to build source code that you plan to distribute publicly, where you can’t be sure of the Python version that an anonymous remote user might use to try to build your software.

SCons provides an EnsurePythonVersion function for this. You simply pass it the major and minor versions numbers of the version of Python you require:

```
EnsurePythonVersion(2, 5)
```

And then SCons will exit with the following error message when a user runs it with an unsupported earlier version of Python:

```
% scons -Q
Python 2.5 or greater required, but you have Python 2.3.6
```

28.2. Verifying the SCons Version: the EnsureSConsVersion Function

You may, of course, write your SConscript files to use features that were only added in recent versions of SCons. When you publicly distribute software that is built using SCons, it’s helpful to have SCons verify the version being used and exit gracefully with an error message if the user’s version of SCons won’t work with your SConscript files. SCons provides an EnsureSConsVersion function that verifies the version of SCons in the same the EnsurePythonVersion function verifies the version of Python, by passing in the major and minor versions numbers of the version of SCons you require:

```
EnsureSConsVersion(1, 0)
```
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And then SCons will exit with the following error message when a user runs it with an unsupported earlier version of SCons:

```
% scons -Q
SCons 1.0 or greater required, but you have SCons 0.98.5
```

### 28.3. Explicitly Terminating SCons While Reading

**SConscript Files: the Exit Function**

SCons supports an `Exit` function which can be used to terminate SCons while reading the SConscript files, usually because you’ve detected a condition under which it doesn’t make sense to proceed:

```python
if ARGUMENTS.get('FUTURE'):
    print "The FUTURE option is not supported yet!"
    Exit(2)
env = Environment()
env.Program('hello.c')
```

```
% scons -Q FUTURE=1
The FUTURE option is not supported yet!
% scons -Q
cc -o hello.o -c hello.c
cc -o hello hello.o
```

The `Exit` function takes as an argument the (numeric) exit status that you want SCons to exit with. If you don’t specify a value, the default is to exit with 0, which indicates successful execution.

Note that the `Exit` function is equivalent to calling the Python `sys.exit` function (which the it actually calls), but because `Exit` is a SCons function, you don’t have to import the Python `sys` module to use it.

### 28.4. Searching for Files: the FindFile Function

The `FindFile` function searches for a file in a list of directories. If there is only one directory, it can be given as a simple string. The function returns a File node if a matching file exists, or None if no file is found. (See the documentation for the `Glob` function for an alternative way of searching for entries in a directory.)

```python
# one directory
print FindFile('missing', '.')
t = FindFile('exists', '.
print t.__class__, t
```
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% scons -Q
None
SCons.Node.FS.File exists
scons: `.' is up to date.

# several directories
includes = [ '.', 'include', 'src/include' ]
headers = [ 'nonesuch.h', 'config.h', 'private.h', 'dist.h' ]
for hdr in headers:
    print `%s:' % hdr), FindFile(hdr, includes)

% scons -Q
nonesuch.h: None
config.h: config.h
private.h: src/include/private.h
dist.h: include/dist.h
scons: `.' is up to date.

If the file exists in more than one directory, only the first occurrence is returned.

    print FindFile('multiple', [ 'sub1', 'sub2', 'sub3' ])
    print FindFile('multiple', [ 'sub2', 'sub3', 'sub1' ])
    print FindFile('multiple', [ 'sub3', 'sub1', 'sub2' ])

% scons -Q
sub1/multiple
sub2/multiple
sub3/multiple
scons: `.' is up to date.

In addition to existing files, FindFile will also find derived files (that is, non-leaf files) that haven’t been built yet. (Leaf files should already exist, or the build will fail!)

# Neither file exists, so build will fail
Command('derived', 'leaf', 'cat >$TARGET $SOURCE')
print FindFile('leaf', '.')
print FindFile('derived', '.')

% scons -Q
None
derived
scons: *** Source `leaf' not found, needed by target `derived'. Stop.

# Neither file exists, so build will fail
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```
Command('derived', 'leaf', 'cat >$TARGET $SOURCE')
print FindFile('leaf', '.')
print FindFile('derived', '.')

# Only 'leaf' exists
Command('derived', 'leaf', 'cat >$TARGET $SOURCE')
print FindFile('leaf', '.')
print FindFile('derived', '.')

% scons -Q
leaf
derived
cat > derived leaf
```

If a source file exists, `FindFile` will correctly return the name in the build directory.

```
# Only 'src/leaf' exists
VariantDir('build', 'src')
print FindFile('leaf', 'build')

% scons -Q
build/leaf
scons: '.' is up to date.
```

### 28.5. Handling Nested Lists: the `Flatten` Function

SCons supports a `Flatten` function which takes an input Python sequence (list or tuple) and returns a flattened list containing just the individual elements of the sequence. This can be handy when trying to examine a list composed of the lists returned by calls to various Builders. For example, you might collect object files built in different ways into one call to the `Program` Builder by just enclosing them in a list, as follows:

```
objects = [
    Object('prog1.c'),
    Object('prog2.c', CCFLAGS='-DFOO'),
]
Program(objects)
```

Because the Builder calls in SCons flatten their input lists, this works just fine to build the program:

```
% scons -Q
cc -o prog1.o -c prog1.c
cc -o prog2.o -c -DFOO prog2.c
```
But if you were debugging your build and wanted to print the absolute path of each object file in the `objects` list, you might try the following simple approach, trying to print each Node’s `abspath` attribute:

```python
objects = [
    Object('prog1.c'),
    Object('prog2.c', CCFLAGS='-DFOO'),
]
Program(objects)

for object_file in objects:
    print object_file.abspath
```

This does not work as expected because each call to `str` is operating an embedded list returned by each `Object` call, not on the underlying Nodes within those lists:

```
% scons -Q
AttributeError: NodeList instance has no attribute 'abspath':
File "~/home/my/project/SConstruct", line 8:
    print object_file.abspath
```

The solution is to use the `Flatten` function so that you can pass each Node to the `str` separately:

```python
objects = [
    Object('prog1.c'),
    Object('prog2.c', CCFLAGS='-DFOO'),
]
Program(objects)

for object_file in Flatten(objects):
    print object_file.abspath
```

```
% scons -Q
/home/me/project/prog1.o
/home/me/project/prog2.o
cc -o prog1.o -c prog1.c
cc -o prog2.o -c -DFOO prog2.c
cc -o prog1 prog1.o prog2.o
```

If you need to find the directory from which the user invoked the scons command, you can use the GetLaunchDir function:

```python
env = Environment(
    LAUNCHDIR = GetLaunchDir(),
)
env.Command('directory_build_info',
    '${LAUNCHDIR}/build_info'
    Copy('${TARGET}', '${SOURCE}')
)
```

Because SCons is usually invoked from the top-level directory in which the SConstruct file lives, the Python os.getcwd() is often equivalent. However, the SCons -u, -U and -D command-line options, when invoked from a subdirectory, will cause SCons to change to the directory in which the SConstruct file is found. When those options are used, GetLaunchDir will still return the path to the user's invoking subdirectory, allowing the SConscript configuration to still get at configuration (or other) files from the originating directory.
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The experience of configuring any software build tool to build a large code base usually, at some point, involves trying to figure out why the tool is behaving a certain way, and how to get it to behave the way you want. SCons is no different. This appendix contains a number of different ways in which you can get some additional insight into SCons’ behavior.

Note that we’re always interested in trying to improve how you can troubleshoot configuration problems. If you run into a problem that has you scratching your head, and which there just doesn’t seem to be a good way to debug, odds are pretty good that someone else will run into the same problem, too. If so, please let the SCons development team know (preferably by filing a bug report or feature request at our project pages at tigris.org) so that we can use your feedback to try to come up with a better way to help you, and others, get the necessary insight into SCons behavior to help identify and fix configuration issues.

29.1. Why is That Target Being Rebuilt? the \texttt{--debug=explain} Option

Let’s look at a simple example of a misconfigured build that causes a target to be rebuilt every time SCons is run:

```
# Intentionally misspell the output file name in the # command used to create the file:
Command('file.out', 'file.in', 'cp $SOURCE file.oout')
```

(Note to Windows users: The POSIX cp command copies the first file named on the command line to the second file. In our example, it copies the file.in file to the file.out file.)

Now if we run SCons multiple times on this example, we see that it re-runs the cp command every time:

```
% scons -Q
  cp file.in file.oout
% scons -Q
  cp file.in file.oout
% scons -Q
  cp file.in file.oout
```

In this example, the underlying cause is obvious: we’ve intentionally misspelled the output file name in the cp command, so the command doesn’t actually build the file.out file that we’ve told SCons to expect. But if the problem weren’t obvious, it would be helpful to specify the \texttt{--debug=explain} option on the command line to have SCons tell us very specifically why it’s decided to rebuild the target:
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% scons -Q --debug=explain
scons: building ‘file.out’ because it doesn’t exist
cp file.in file.out

If this had been a more complicated example involving a lot of build output, having SCons tell us that it’s trying to rebuild the target file because it doesn’t exist would be an important clue that something was wrong with the command that we invoked to build it.

The --debug=explain option also comes in handy to help figure out what input file changed. Given a simple configuration that builds a program from three source files, changing one of the source files and rebuilding with the --debug=explain option shows very specifically why SCons rebuilds the files that it does:

% scons -Q
cc -o file1.o -c file1.c
c -o file2.o -c file2.c
c -o file3.o -c file3.c
c -o prog file1.o file2.o file3.o
% edit file2.c
[CHANGE THE CONTENTS OF file2.c]
% scons -Q --debug=explain
scons: rebuilding ‘file2.o’ because ‘file2.c’ changed
cc -o file2.o -c file2.c
scons: rebuilding ‘prog’ because ‘file2.o’ changed
c -o prog file1.o file2.o file3.o

This becomes even more helpful in identifying when a file is rebuilt due to a change in an implicit dependency, such as an included .h file. If the file1.c and file3.c files in our example both included a hello.h file, then changing that included file and re-running SCons with the --debug=explain option will pinpoint that it’s the change to the included file that starts the chain of rebuilds:

% scons -Q
cc -o file1.o -c -I. file1.c
c -o file2.o -c -I. file2.c
c -o file3.o -c -I. file3.c
c -o prog file1.o file2.o file3.o
% edit hello.h
[CHANGE THE CONTENTS OF hello.h]
% scons -Q --debug=explain
scons: rebuilding ‘file1.o’ because ‘hello.h’ changed
c -o file1.o -c -I. file1.c
scons: rebuilding ‘file3.o’ because ‘hello.h’ changed
c -o file3.o -c -I. file3.c
scons: rebuilding ‘prog’ because:
  ‘file1.o’ changed
  ‘file3.o’ changed
c -o prog file1.o file2.o file3.o
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(Note that the `--debug=explain` option will only tell you why SCons decided to rebuild necessary targets. It does not tell you what files it examined when deciding not to rebuild a target file, which is often a more valuable question to answer.)

29.2. What’s in That Construction Environment? the Dump Method

When you create a construction environment, SCons populates it with construction variables that are set up for various compilers, linkers and utilities that it finds on your system. Although this is usually helpful and what you want, it might be frustrating if SCons doesn’t set certain variables that you expect to be set. In situations like this, it’s sometimes helpful to use the construction environment `Dump` method to print all or some of the construction variables. Note that the `Dump` method returns the representation of the variables in the environment for you to print (or otherwise manipulate):

```python
env = Environment()
print env.Dump()
```

On a POSIX system with gcc installed, this might generate:

```bash
% scons
scons: Reading SConscript files ...
{ 'BUILDERS': {'_InternalInstall': <function InstallBuilderWrapper at 0x700000>, '_InternalInstallAs': <function InstallAsBuilderWrapper at 0x700000>}, 'CONFIGUREDIR': '/.sconf_temp', 'CONFIGURELOG': '/config.log', 'CPPSUFFIXES': [ '.c', '.C', '.cxx', '.cpp', '.c++', '.cc', '.h', '.H', '.hxx', '.hpp', '.hh', '.F', '.fpp', '.FP', '.m', '.mm', '.S', '.spp', '.SPP'], 'DSUFFIXES': ['.d'], 'Dir': <SCons.Defaults.Variable_MethodCaller instance at 0x700000>, 'Dirs': <SCons.Defaults.Variable_MethodCaller instance at 0x700000>, 'ENV': {'PATH': '/usr/local/bin:/opt/bin:/bin:/usr/bin'}},
```

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On a Windows system with Visual C++ the output might look like:

C:\>scons
scons: Reading SConscript files ...
| 'BUILDERS': {'_InternalInstall': <function InstallBuilderWrapper at 0x700000>, 'Object': ... instance at 0x700000>, '_InternalInstallAs': <function InstallAsBuilderWrapper at 0x700000>},
| 'CC': 'cl',
| 'CCCOM': <SCons.Action.FunctionAction instance at 0x700000>,
| 'CCFLAGS': ['/nologo'],
| 'CCPCHFLAGS': ['$({(PCH and "/Yu%s /Fp%s"%(PCHSTOP or "",File(PCH))) or "")',
| 'CCPDBFLAGS': '${(_concat(LIBDIRPREFIX, LIBPATH, LIBDIRSUFFIX, __env__, RDirs, TARGET, SOURCE))}',
| 'LIBDIRFLAGS': '${(_concat(LIBDIRPREFIX, LIBPATH, LIBDIRSUFFIX, __env__, RDirs, TARGET, SOURCE))}',
| 'LIBFLAGS': '${(_concat(LIBLINKPREFIX, LIBS, LIBLINKSUFFIX, __env__))}',
| 'RPATH': '${_RPATH}',
| '_concat': <function _concat at 0x700000>,
| '_defines': <function _defines at 0x700000>,
| '_stripixes': <function _stripixes at 0x700000>}

scons: done reading SConscript files.
scons: Building targets ...
scons: '.' is up to date.
scons: done building targets.
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'CFLAGS': [],
'CONFIGUREDIR': '#/.sconf_temp',
'CONFIGURELOG': '#/config.log',
'CPPDEFPREFIX': '/D',
'CPPDEFSUFFIX': '',
'CPPSUFFIXES': ['.c',
',.C',
',.cxx',
',.cpp',
',.c++',
',.cc',
',.h',
',.H',
',.hxx',
',.hpp',
',.hh',
',.F',
',.cpp',
',.FPP',
',.m',
',.mm',
',.S',
',.spp',
',.SPP'],
'CXX': '$CC',
'CXXCOM': '$CXX /Fo$TARGET /c $SOURCES $CXXFLAGS $CCFLAGS $_CCCOMCOM',
'CXXFILESUFFIX': '.cc',
'CXXFLAGS': ['$CCFLAGS', '$(', '/TP', '$)'],
'DSUFFIXES': ['.d'],
'Dir': <SCons.Defaults.Variable_Method_Caller instance at 0x700000>,
'Dirs': <SCons.Defaults.Variable_Method_Caller instance at 0x700000>,
'ENV': {'INCLUDE': 'C:\Program Files\Microsoft Visual Studio/VC98\include',
'LIB': 'C:\Program Files\Microsoft Visual Studio/VC98\lib',
'PATH': 'C:\Program Files\Microsoft Visual Studio\Common\tools\WIN95;C:\Program Files\Microsoft Visual Studio\Common\tools;C:\Program Files\Microsoft Visual Studio/VC98\bin',
'PATHEXT': '.COM;.EXE;.BAT;.CMD',
'SystemRoot': 'C:/WINDOWS'},
'ESCAPE': <function escape at 0x700000>,
'File': <SCons.Defaults.Variable_Method_Caller instance at 0x700000>,
'IDLSUFFIXES': ['.idl', '.IDL'],
'INCPREFIX': '/I',
'INCSUFFIX': '',
'INSTALL': <function copyFunc at 0x700000>,
'LATEXSUFFIXES': ['.tex', '.ltx', '.latex'],
'LIBPREFIX': '',
'LIBPREFIXES': ['$LIBPREFIX'],
'LIBSUFFIX': '.lib',
'LIBSUFFIXES': ['$LIBSUFFIX'],
'MAXLINELENGTH': 2048,
'MSVS': {'VERSION': '6.0', 'VERSIONS': ['6.0']},
'MSVS_VERSION': '6.0',
'OBJPREFIX': '',
'OBJSUFFIX': '.obj',
'PCHCOM': '$CXX $CXXFLAGS $CPPFLAGS $_CPPDEFFLAGS $_CPPINCFLAGS /c $SOURCES /Fo$TARGET'}
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The construction environments in these examples have actually been restricted to just gcc and Visual C++, respectively. In a real-life situation, the construction environments will likely contain a great many more variables. Also note that we’ve massaged the example output above to make the memory address of all objects a constant 0x700000. In reality, you would see a different hexadecimal number for each object.

To make it easier to see just what you’re interested in, the Dump method allows you to specify a specific construction variable that you want to display. For example, it’s not unusual to want to verify the external
environment used to execute build commands, to make sure that the PATH and other environment variables are set up the way they should be. You can do this as follows:

```python
env = Environment()
print env.Dump('ENV')
```

Which might display the following when executed on a POSIX system:

```
% scons
scons: Reading SConscript files ...
{'PATH': '/usr/local/bin:/opt/bin:/bin:/usr/bin'}
scons: done reading SConscript files.
scons: Building targets ...
scons: ‘.’ is up to date.
scons: done building targets.
```

And the following when executed on a Windows system:

```
C:\>scons
scons: Reading SConscript files ...
{ 'INCLUDE': 'C:\Program Files\Microsoft Visual Studio/VC98\include',
  'LIB': 'C:\Program Files\Microsoft Visual Studio/VC98\lib',
  'PATH': 'C:\Program Files\Microsoft Visual Studio\Common\tools\WIN95;C:\Program Files\Microsoft Visual Studio\Common\tools;C:\Program Files\Microsoft Visual Studio\Common\tools;C:\Program Files\Microsoft Visual Studio/VC98\bin',
  'PATHEXT': '.COM;.EXE;.BAT;.CMD',
  'SystemRoot': 'C:/WINDOWS'}
scons: done reading SConscript files.
scons: Building targets ...
scons: ‘.’ is up to date.
scons: done building targets.
```

### 29.3. What Dependencies Does SCons Know About? the --tree Option

Sometimes the best way to try to figure out what SCons is doing is simply to take a look at the dependency graph that it constructs based on your SConscript files. The --tree option will display all or part of the SCons dependency graph in an "ASCII art" graphical format that shows the dependency hierarchy.

For example, given the following input SConstruct file:

```python
env = Environment(CPPPATH = ['.'])
env.Program('prog', ['f1.c', 'f2.c', 'f3.c'])
```
Running SCons with the \texttt{--tree=all} option yields:

\begin{verbatim}
\%
\textbf{scons} \texttt{-Q --tree=all}
\textbf{cc} \texttt{-o} \textbf{f1.o} \texttt{-c -I. f1.c}
\textbf{cc} \texttt{-o} \textbf{f2.o} \texttt{-c -I. f2.c}
\textbf{cc} \texttt{-o} \textbf{f3.o} \texttt{-c -I. f3.c}
\textbf{cc} \texttt{-o} \textbf{prog} \textbf{f1.o} \textbf{f2.o} \textbf{f3.o}
\texttt{+--.}
\texttt{+-SConstruct}
\texttt{+-f1.c}
\texttt{ | \+-f1.o}
\texttt{ | \+-inc.h}
\texttt{+-f2.c}
\texttt{ | \+-f2.o}
\texttt{ | \+-inc.h}
\texttt{+-f3.c}
\texttt{ | \+-f3.o}
\texttt{ | \+-inc.h}
\texttt{+-prog}
\texttt{ +-f1.o}
\texttt{ | \+-f1.c}
\texttt{ | \+-inc.h}
\texttt{+-f2.o}
\texttt{ | \+-f2.c}
\texttt{ | \+-inc.h}
\texttt{+-f3.o}
\texttt{ \+-f3.c}
\texttt{ \+-inc.h}
\%
\end{verbatim}

The tree will also be printed when the \texttt{--n} (no execute) option is used, which allows you to examine the dependency graph for a configuration without actually rebuilding anything in the tree.

The \texttt{--tree} option only prints the dependency graph for the specified targets (or the default target(s) if none are specified on the command line). So if you specify a target like \texttt{f2.o} on the command line, the \texttt{--tree} option will only print the dependency graph for that file:

\begin{verbatim}
\%
\textbf{scons} \texttt{-Q --tree=all f2.o}
\textbf{cc} \texttt{-o} \textbf{f2.o} \texttt{-c -I. f2.c}
\texttt{+-f2.o}
\texttt{ \+-f2.c}
\texttt{ \+-inc.h}
\%
\end{verbatim}
This is, of course, useful for restricting the output from a very large build configuration to just a portion in which you’re interested. Multiple targets are fine, in which case a tree will be printed for each specified target:

```
% scons -Q --tree=all f1.o f3.o
cc -o f1.o -c -I. f1.c
+--f1.o
|  +--f1.c
|  +--inc.h
cc -o f3.o -c -I. f3.c
+--f3.o
|  +--f3.c
|  +--inc.h
```

The `status` argument may be used to tell SCons to print status information about each file in the dependency graph:

```
% scons -Q --tree=status
cc -o f1.o -c -I. f1.c
cc -o f2.o -c -I. f2.c
cc -o f3.o -c -I. f3.c
cc -o prog f1.o f2.o f3.o
E   = exists
R   = exists in repository only
b   = implicit builder
B   = explicit builder
S   = side effect
P   = precious
A   = always build
C   = current
N   = no clean
H   = no cache

[E b]  +--.
[E C]  +--SConstruct
[E C]   +--f1.c
[E B C]  +--f1.o
[E C]    |  +--f1.c
[E C]    |  +--inc.h
[E C]   +--f2.c
[E B C]  +--f2.o
[E C]    |  +--f2.c
[E C]    |  +--inc.h
[E C]   +--f3.c
[E B C]  +--f3.o
[E C]    |  +--f3.c
[E C]    |  +--inc.h
[E C]   +--inc.h
[E B C]  +--prog
[E B C]   +--f1.o
[E C]    |  +--f1.c
```

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Note that `--tree=all,status` is equivalent; the all is assumed if only status is present. As an alternative to all, you can specify `--tree=derived` to have SCons only print derived targets in the tree output, skipping source files (like .c and .h files):

```
% scons -Q --tree=derived
cc -o f1.o -c -I. f1.c
cc -o f2.o -c -I. f2.c
cc -o f3.o -c -I. f3.c
cc -o prog f1.o f2.o f3.o
+-.
  +-f1.o
  +-f2.o
  +-f3.o
  +-prog
  +-f1.o
  +-f2.o
  +-f3.o
```

You can use the status modifier with derived as well:

```
% scons -Q --tree=derived,status
cc -o f1.o -c -I. f1.c
cc -o f2.o -c -I. f2.c
cc -o f3.o -c -I. f3.c
cc -o prog f1.o f2.o f3.o
E   = exists
R   = exists in repository only
b   = implicit builder
B   = explicit builder
S   = side effect
P   = precious
A   = always build
C   = current
N   = no clean
H   = no cache

[E b ]+-.
[E B C ] +-f1.o
[E B C ] +-f2.o
[E B C ] +-f3.o
[E B C ] +-prog
```
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Note that the order of the \texttt{--tree=} arguments doesn’t matter; \texttt{--tree=status,derived} is completely equivalent.

The default behavior of the \texttt{--tree} option is to repeat all of the dependencies each time the library dependency (or any other dependency file) is encountered in the tree. If certain target files share other target files, such as two programs that use the same library:

\begin{verbatim}
env = Environment(CPPPATH = ['.'],
                 LIBS = ['foo'],
                 LIBPATH = ['.'])
env.Library('foo', ['f1.c', 'f2.c', 'f3.c'])
env.Program('prog1.c')
env.Program('prog2.c')
\end{verbatim}

Then there can be a \textit{lot} of repetition in the \texttt{--tree=} output:

\begin{verbatim}
% scons -Q --tree=all
cc -o f1.o -c -I. f1.c
cc -o f2.o -c -I. f2.c
cc -o f3.o -c -I. f3.c
ar rc libfoo.a f1.o f2.o f3.o
ranlib libfoo.a
cc -o prog1.o -c -I. prog1.c
cc -o prog1 prog1.o -L. -lfoo
cc -o prog2.o -c -I. prog2.c
cc -o prog2 prog2.o -L. -lfoo
+-...
  +-SConstruct
  +-f1.c
  +-f1.o
   |   +-f1.c
   |   +-inc.h
   +-f2.c
   +-f2.o
   |   +-f2.c
   |   +-inc.h
   +-f3.c
   +-f3.o
   |   +-f3.c
   |   +-inc.h
   +-inc.h
   +-libfoo.a
   |   +-f1.o
   |   |   +-f1.c
\end{verbatim}
In a large configuration with many internal libraries and include files, this can very quickly lead to huge output trees. To help make this more manageable, a prune modifier may be added to the option list, in which case SCons will print the name of a target that has already been visited during the tree-printing in [square brackets] as an indication that the dependencies of the target file may be found by looking farther up the tree:

```
% scons -Q --tree=prune
```
Like the status keyword, the prune argument by itself is equivalent to --tree=all, prune.
29.4. How is SCons Constructing the Command Lines It Executes? the \texttt{--debug=presub} Option

Sometimes it’s useful to look at the pre-substitution string that SCons uses to generate the command lines it executes. This can be done with the \texttt{--debug=presub} option:

\begin{verbatim}
% scons -Q --debug=presub
Building prog.o with action:
  $CC -o $TARGET -c $CFLAGS $CCFLAGS $_CCOMCOM $SOURCES
  cc -o prog.o -c -I. prog.c
Building prog with action:
  $SMART_LINKCOM
  cc -o prog prog.o
\end{verbatim}

29.5. Where is SCons Searching for Libraries? the \texttt{--debug=findlibs} Option

To get some insight into what library names SCons is searching for, and in which directories it is searching, Use the \texttt{--debug=findlibs} option. Given the following input SConstruct file:

\begin{verbatim}
env = Environment(LIBPATH = ['libs1', 'libs2'])
env.Program('prog.c', LIBS=['foo', 'bar'])
\end{verbatim}

And the libraries \texttt{libfoo.a} and \texttt{libbar.a} in \texttt{libs1} and \texttt{libs2}, respectively, use of the \texttt{--debug=findlibs} option yields:

\begin{verbatim}
% scons -Q --debug=findlibs
findlibs: looking for ’libfoo.a’ in ’libs1’ ...
findlibs: ... FOUND ’libfoo.a’ in ’libs1’
findlibs: looking for ’libfoo.so’ in ’libs1’ ...
findlibs: looking for ’libfoo.so’ in ’libs2’ ...
findlibs: looking for ’libbar.a’ in ’libs1’ ...
findlibs: looking for ’libbar.a’ in ’libs2’ ...
findlibs: ... FOUND ’libbar.a’ in ’libs2’
findlibs: looking for ’libbar.so’ in ’libs1’ ...
findlibs: looking for ’libbar.so’ in ’libs2’ ...
cc -o prog.o -c prog.c
cc -o prog prog.o -Llibs1 -Llibs2 -lfoo -lbar
\end{verbatim}
29.6. Where is SCons Blowing Up? the --debug=stacktrace Option

In general, SCons tries to keep its error messages short and informative. That means we usually try to avoid showing the stack traces that are familiar to experienced Python programmers, since they usually contain much more information than is useful to most people.

For example, the following SConstruct file:

```python
Program('prog.c')
```

Generates the following error if the `prog.c` file does not exist:

```
% scons -Q
scons: *** Source 'prog.c' not found, needed by target 'prog.o'. Stop.
```

In this case, the error is pretty obvious. But if it weren’t, and you wanted to try to get more information about the error, the `--debug=stacktrace` option would show you exactly where in the SCons source code the problem occurs:

```
% scons -Q --debug=stacktrace
scons: *** Source 'prog.c' not found, needed by target 'prog.o'. Stop.
scons: internal stack trace:
  File "bootstrap/src/engine/SCons/Job.py", line 197, in start
  File "bootstrap/src/engine/SCons/Script/Main.py", line 167, in prepare
  File "bootstrap/src/engine/SCons/Taskmaster.py", line 182, in prepare
  File "bootstrap/src/engine/SCons/Executor.py", line 171, in prepare
```

Of course, if you do need to dive into the SCons source code, we’d like to know if, or how, the error messages or troubleshooting options could have been improved to avoid that. Not everyone has the necessary time or Python skill to dive into the source code, and we’d like to improve SCons for those people as well...

29.7. How is SCons Making Its Decisions? the --taskmastertrace Option

The internal SCons subsystem that handles walking the dependency graph and controls the decision-making about what to rebuild is the Taskmaster. SCons supports the `--taskmastertrace` option that tells the Taskmaster to print information about the children (dependencies) of the various...
Nodes on its walk down the graph, which specific dependent Nodes are being evaluated, and in what order.

The \texttt{--taskmastertrace} option takes as an argument the name of a file in which to put the trace output, with - (a single hyphen) indicating that the trace messages should be printed to the standard output:

\begin{verbatim}
env = Environment(CPPPATH = ['.'])
env.Program('prog.c')

% scons -Q --taskmastertrace=- prog

Taskmaster: Looking for a node to evaluate
Taskmaster: Considering node <no_state 0 'prog'> and its children:
Taskmaster:  <no_state 0 'prog.o'>
Taskmaster:    adjusting ref count: <pending 1 'prog'>
Taskmaster: Considering node <no_state 0 'prog.o'> and its children:
Taskmaster:  <no_state 0 'prog.c'>
Taskmaster:  <no_state 0 'inc.h'>
Taskmaster:    adjusting ref count: <pending 1 'prog.o'>
Taskmaster:    adjusting ref count: <pending 2 'prog.o'>
Taskmaster: Considering node <no_state 0 'prog.c'> and its children:
Taskmaster: Evaluating <pending 0 'prog.c'>

Taskmaster: Looking for a node to evaluate
Taskmaster: Considering node <no_state 0 'inc.h'> and its children:
Taskmaster: Evaluating <pending 0 'inc.h'>

Taskmaster: Looking for a node to evaluate
Taskmaster: Considering node <pending 0 'prog.o'> and its children:
Taskmaster:  <up_to_date 0 'prog.c'>
Taskmaster:  <up_to_date 0 'inc.h'>
Taskmaster: Evaluating <pending 0 'prog.o'>
cc -o prog.o -c -I. prog.c

Taskmaster: Looking for a node to evaluate
Taskmaster: Considering node <pending 0 'prog'> and its children:
Taskmaster:  <executed 0 'prog.o'>
Taskmaster: Evaluating <pending 0 'prog'>
cc -o prog prog.o

Taskmaster: Looking for a node to evaluate
Taskmaster: No candidate anymore.
\end{verbatim}

The \texttt{--taskmastertrace} option doesn’t provide information about the actual calculations involved in deciding if a file is up-to-date, but it does show all of the dependencies it knows about for each Node, and the order in which those dependencies are evaluated. This can be useful as an alternate way to determine whether or not your SCons configuration, or the implicit dependency scan, has actually identified all the correct dependencies you want it to.
Appendix A. Construction Variables

This appendix contains descriptions of all of the construction variables that are potentially available "out of the box" in this version of SCons. Whether or not setting a construction variable in a construction environment will actually have an effect depends on whether any of the Tools and/or Builders that use the variable have been included in the construction environment.

In this appendix, we have appended the initial $ (dollar sign) to the beginning of each variable name when it appears in the text, but left off the dollar sign in the left-hand column where the name appears for each entry.

AR
The static library archiver.

ARCHITECTURE
Specifies the system architecture for which the package is being built. The default is the system architecture of the machine on which SCons is running. This is used to fill in the Architecture: field in an Ipkg control file, and as part of the name of a generated RPM file.

ARCOM
The command line used to generate a static library from object files.

ARCOMSTR
The string displayed when an object file is generated from an assembly-language source file. If this is not set, then $ARCOM (the command line) is displayed.

env = Environment(ARCOMSTR = "Archiving $TARGET")

ARFLAGS
General options passed to the static library archiver.

AS
The assembler.

ASCOM
The command line used to generate an object file from an assembly-language source file.

ASCOMSTR
The string displayed when an object file is generated from an assembly-language source file. If this is not set, then $ASCOM (the command line) is displayed.

env = Environment(ASCOMSTR = "Assembling $TARGET")

ASFLAGS
General options passed to the assembler.
Appendix A. Construction Variables

ASPPCOM

The command line used to assemble an assembly-language source file into an object file after first running the file through the C preprocessor. Any options specified in the $ASFLAGS and $CPPFLAGS construction variables are included on this command line.

ASPPCOMSTR

The string displayed when an object file is generated from an assembly-language source file after first running the file through the C preprocessor. If this is not set, then $ASPPCOM (the command line) is displayed.

```
env = Environment(ASPPCOMSTR = "Assembling $TARGET")
```

ASPPFLAGS

General options when assembling an assembly-language source file into an object file after first running the file through the C preprocessor. The default is to use the value of $ASFLAGS.

BIBTEX

The bibliography generator for the TeX formatter and typesetter and the LaTeX structured formatter and typesetter.

BIBTEXCOM

The command line used to call the bibliography generator for the TeX formatter and typesetter and the LaTeX structured formatter and typesetter.

BIBTEXCOMSTR

The string displayed when generating a bibliography for TeX or LaTeX. If this is not set, then $BIBTEXCOM (the command line) is displayed.

```
env = Environment(BIBTEXCOMSTR = "Generating bibliography $TARGET")
```

BIBTEXFLAGS

General options passed to the bibliography generator for the TeX formatter and typesetter and the LaTeX structured formatter and typesetter.

BITKEEPER

The BitKeeper executable.

BITKEEPERCOM

The command line for fetching source files using BitKeeper.

BITKEEPERCOMSTR

The string displayed when fetching a source file using BitKeeper. If this is not set, then $BITKEEPERCOM (the command line) is displayed.

BITKEEPERGET

The command ($BITKEEPER) and subcommand for fetching source files using BitKeeper.
Appendix A. Construction Variables

BITKEEPERGETFLAGS
Options that are passed to the BitKeeper get subcommand.

BUILDERS
A dictionary mapping the names of the builders available through this environment to underlying Builder objects. Builders named Alias, CFile, CXXFile, DVI, Library, Object, PDF, PostScript, and Program are available by default. If you initialize this variable when an Environment is created:

```python
env = Environment(BUILDERS = {'NewBuilder': foo})
```

the default Builders will no longer be available. To use a new Builder object in addition to the default Builders, add your new Builder object like this:

```python
env = Environment()
env.Append(BUILDERS = {'NewBuilder': foo})
```

or this:

```python
env = Environment()
env['BUILDERS']['NewBuilder'] = foo
```

CC
The C compiler.

CCCOM
The command line used to compile a C source file to a (static) object file. Any options specified in the $CFLAGS, $CCFLAGS and $CPPFLAGS construction variables are included on this command line.

CCCOMSTR
The string displayed when a C source file is compiled to a (static) object file. If this is not set, then $CCCOM (the command line) is displayed.

```python
env = Environment(CCCOMSTR = "Compiling static object $TARGET")
```

CCFLAGS
General options that are passed to the C and C++ compilers.

CCPCHFLAGS
Options added to the compiler command line to support building with precompiled headers. The default value expands to the appropriate Microsoft Visual C++ command-line options when the $PCH construction variable is set.

CCPDBFLAGS
Options added to the compiler command line to support storing debugging information in a Microsoft Visual C++ PDB file. The default value expands to appropriate Microsoft Visual C++ command-line options when the $PDB construction variable is set.
Appendix A. Construction Variables

The Visual C++ compiler option that SCons uses by default to generate PDB information is /Z7. This works correctly with parallel (-j) builds because it embeds the debug information in the intermediate object files, as opposed to sharing a single PDB file between multiple object files. This is also the only way to get debug information embedded into a static library. Using the /Zi instead may yield improved link-time performance, although parallel builds will no longer work.

You can generate PDB files with the /Zi switch by overriding the default $CCPDBFLAGS variable as follows:

```python
env['CCPDBFLAGS'] = ['$\{\text{PDB and } /Zi /Fd\text{\% File(PDB)} \text{ or } ""\}'
```

An alternative would be to use the /Zi to put the debugging information in a separate .pdb file for each object file by overriding the $CCPDBFLAGS variable as follows:

```python
env['CCPDBFLAGS'] = '/Zi /Fd\{TARGET\}.pdb'
```

CCVERSION

The version number of the C compiler. This may or may not be set, depending on the specific C compiler being used.

CFILESUFFIX

The suffix for C source files. This is used by the internal CFile builder when generating C files from Lex (.l) or YACC (.y) input files. The default suffix, of course, is .c (lower case). On case-insensitive systems (like Windows), SCons also treats .C (upper case) files as C files.

CFLAGS

General options that are passed to the C compiler (C only; not C++).

CHANGE_SPECFILE

A hook for modifying the file that controls the packaging build (the .spec for RPM, the control for Ipkg, the .wxs for MSI). If set, the function will be called after the SCons template for the file has been written. XXX

CHANGELOG

The name of a file containing the change log text to be included in the package. This is included as the %changelog section of the RPM .spec file.

_concat

A function used to produce variables like $_CPPINCFLAGS. It takes four or five arguments: a prefix to concatenate onto each element, a list of elements, a suffix to concatenate onto each element, an environment for variable interpolation, and an optional function that will be called to transform the list before concatenation.

```python
env['_CPPINCFLAGS'] = '$\{\text{concat(INCPREFIX, CPPPATH, INCSUFFIX, __env__, RDirs)} \text{ \$}'
```

CONFIGUREDIR

The name of the directory in which Configure context test files are written. The default is .sconf_temp in the top-level directory containing the SConstruct file.
Appendix A. Construction Variables

CONFIGURELOG

The name of the Configure context log file. The default is config.log in the top-level directory containing the SConstruct file.

_CPPDEFFLAGS

An automatically-generated construction variable containing the C preprocessor command-line options to define values. The value of $_CPPDEFFLAGS is created by appending $CPPDEFPREFIX and $CPPDEFSUFFIX to the beginning and end of each directory in $CPPDEFINES.

CPPDEFINES

A platform independent specification of C preprocessor definitions. The definitions will be added to command lines through the automatically-generated $_CPPDEFFLAGS construction variable (see above), which is constructed according to the type of value of $CPPDEFINES:

If $CPPDEFINES is a string, the values of the $CPPDEFPREFIX and $CPPDEFSUFFIX construction variables will be added to the beginning and end.

# Will add -Dxyz to POSIX compiler command lines,  
# and /Dxyz to Microsoft Visual C++ command lines.  
env = Environment(CPPDEFINES='xyz')

If $CPPDEFINES is a list, the values of the $CPPDEFPREFIX and $CPPDEFSUFFIX construction variables will be appended to the beginning and end of each element in the list. If any element is a list or tuple, then the first item is the name being defined and the second item is its value.

# Will add -DB=2 -DA to POSIX compiler command lines,  
# and /DB=2 /DA to Microsoft Visual C++ command lines.  
env = Environment(CPPDEFINES=[('B', 2), 'A'])

If $CPPDEFINES is a dictionary, the values of the $CPPDEFPREFIX and $CPPDEFSUFFIX construction variables will be appended to the beginning and end of each item from the dictionary. The key of each dictionary item is a name being defined to the dictionary item’s corresponding value; if the value is None, then the name is defined without an explicit value. Note that the resulting flags are sorted by keyword to ensure that the order of the options on the command line is consistent each time scons is run.

# Will add -DA -DB=2 to POSIX compiler command lines,  
# and /DA /DB=2 to Microsoft Visual C++ command lines.  
env = Environment(CPPDEFINES={'B':2, 'A':None})

CPPDEFPREFIX

The prefix used to specify preprocessor definitions on the C compiler command line. This will be appended to the beginning of each definition in the $CPPDEFINES construction variable when the $_CPPDEFFLAGS variable is automatically generated.
CPPDEFSUFFIX

The suffix used to specify preprocessor definitions on the C compiler command line. This will be appended to the end of each definition in the $CPPDEFINES construction variable when the $_CPPDEFFLAGS variable is automatically generated.

CPPFLAGS

User-specified C preprocessor options. These will be included in any command that uses the C preprocessor, including not just compilation of C and C++ source files via the $CCCOM, $SSHCCCOM, $CXXCOM and $SHCXXCOM command lines, but also the $FORTRANPPCOM, $SSHFORTRANPPCOM, $F77PPCOM and $SHF77PPCOM command lines used to compile a Fortran source file, and the $ASPPCOM command line used to assemble an assembly language source file, after first running each file through the C preprocessor. Note that this variable does not contain -I (or similar) include search path options that scons generates automatically from CPPPATH. See $_CPPINCFLAGS, below, for the variable that expands to those options.

_CPPINCFLAGS

An automatically-generated construction variable containing the C preprocessor command-line options for specifying directories to be searched for include files. The value of $_CPPINCFLAGS is created by appending SINCPREFIX and SINCUFFIX to the beginning and end of each directory in CPPPATH.

CPPPATH

The list of directories that the C preprocessor will search for include directories. The C/C++ implicit dependency scanner will search these directories for include files. Don’t explicitly put include directory arguments in CCFLAGS or CXXFLAGS because the result will be non-portable and the directories will not be searched by the dependency scanner. Note: directory names in CPPPATH will be looked-up relative to the SConscript directory when they are used in a command. To force scons to look-up a directory relative to the root of the source tree use #:

```python
env = Environment(CPPPATH='#/include')
```

The directory look-up can also be forced using the Dir() function:

```python
include = Dir('include')
env = Environment(CPPPATH=include)
```

The directory list will be added to command lines through the automatically-generated $_CPPINCFLAGS construction variable, which is constructed by appending the values of the SINCPREFIX and SINCUFFIX construction variables to the beginning and end of each directory in CPPPATH. Any command lines you define that need the CPPPATH directory list should include $_CPPINCFLAGS:

```python
env = Environment(CCCOM="my_compiler $_CPPINCFLAGS -c -o $TARGET $SOURCE")
```

CPPSUFFIXES

The list of suffixes of files that will be scanned for C preprocessor implicit dependencies (#include lines). The default list is:

```
[".c", ".C", ".cxx", ".cpp", ".c++", ".cc"
```
Appendix A. Construction Variables

".h", ".H", ".hxx", ".hpp", ".hh",
".F", ".fpp", ".FPP",
".m", ".mm",
".S", ".spp", ".SPP"]

CVS
The CVS executable.

CVSCOFLAGS
Options that are passed to the CVS checkout subcommand.

CVSCOM
The command line used to fetch source files from a CVS repository.

CVSCOMSTR
The string displayed when fetching a source file from a CVS repository. If this is not set, then $CVSCOM (the command line) is displayed.

CVSFLAGS
General options that are passed to CVS. By default, this is set to `-d $CVSREPOSITORY` to specify from where the files must be fetched.

CVSREPOSITORY
The path to the CVS repository. This is referenced in the default $CVSFLAGS value.

CXX
The C++ compiler.

CXXCOM
The command line used to compile a C++ source file to an object file. Any options specified in the $CXXFLAGS and $CPPFLAGS construction variables are included on this command line.

CXXCOMSTR
The string displayed when a C++ source file is compiled to a (static) object file. If this is not set, then $CXXCOM (the command line) is displayed.

env = Environment(CXXCOMSTR = "Compiling static object $TARGET")

CXXFILESUFFIX
The suffix for C++ source files. This is used by the internal CXXFile builder when generating C++ files from Lex (.ll) or YACC (.yy) input files. The default suffix is `.cc`. SCons also treats files with the suffixes `.cpp`, `.cxx`, `.c++`, and `.C++` as C++ files, and files with `.mm` suffixes as Objective C++ files. On case-sensitive systems (Linux, UNIX, and other POSIX-alikes), SCons also treats `.c` (upper case) files as C++ files.
Appendix A. Construction Variables

**CXXFLAGS**

General options that are passed to the C++ compiler. By default, this includes the value of $CCFLAGS, so that setting $CCFLAGS affects both C and C++ compilation. If you want to add C++-specific flags, you must set or override the value of $CXXFLAGS.

**CXXVERSION**

The version number of the C++ compiler. This may or may not be set, depending on the specific C++ compiler being used.

**DESCRIPTION**

A long description of the project being packaged. This is included in the relevant section of the file that controls the packaging build.

**DESCRIPTION_lang**

A language-specific long description for the specified lang. This is used to populate a \%description -l section of an RPM .spec file.

**Dir**

A function that converts a string into a Dir instance relative to the target being built.

**Dirs**

A function that converts a list of strings into a list of Dir instances relative to the target being built.

**DSUFFIXES**

The list of suffixes of files that will be scanned for imported D package files. The default list is: [.d]

**DVIPDF**

The TeX DVI file to PDF file converter.

**DVIPDFCOM**

The command line used to convert TeX DVI files into a PDF file.

**DVIPDFCOMSTR**

The string displayed when a TeX DVI file is converted into a PDF file. If this is not set, then $DVIPDFCOM (the command line) is displayed.

**DVIPDFFLAGS**

General options passed to the TeX DVI file to PDF file converter.

**DVIPS**

The TeX DVI file to PostScript converter.

**DVIPSFLAGS**

General options passed to the TeX DVI file to PostScript converter.
Appendix A. Construction Variables

ENV

A dictionary of environment variables to use when invoking commands. When $ENV is used in a command all list values will be joined using the path separator and any other non-string values will simply be coerced to a string. Note that, by default, scons does not propagate the environment in force when you execute scons to the commands used to build target files. This is so that builds will be guaranteed repeatable regardless of the environment variables set at the time scons is invoked.

If you want to propagate your environment variables to the commands executed to build target files, you must do so explicitly:

```python
import os
env = Environment(ENV = os.environ)
```

Note that you can choose only to propagate certain environment variables. A common example is the system PATH environment variable, so that scons uses the same utilities as the invoking shell (or other process):

```python
import os
env = Environment(ENV = {'PATH' : os.environ['PATH']})
```

ESCAPE

A function that will be called to escape shell special characters in command lines. The function should take one argument: the command line string to escape; and should return the escaped command line.

F77

The Fortran 77 compiler. You should normally set the $FORTRAN variable, which specifies the default Fortran compiler for all Fortran versions. You only need to set $F77 if you need to use a specific compiler or compiler version for Fortran 77 files.

F77COM

The command line used to compile a Fortran 77 source file to an object file. You only need to set $F77COM if you need to use a specific command line for Fortran 77 files. You should normally set the $FORTRANCOM variable, which specifies the default command line for all Fortran versions.

F77COMSTR

The string displayed when a Fortran 77 source file is compiled to an object file. If this is not set, then $F77COM or $FORTRANCOM (the command line) is displayed.

F77FILESUFFIXES

The list of file extensions for which the F77 dialect will be used. By default, this is ['.f77'].

F77FLAGS

General user-specified options that are passed to the Fortran 77 compiler. Note that this variable does not contain -I (or similar) include search path options that scons generates automatically from $F77PATH. See $_F77INCFLAGS below, for the variable that expands to those options. You only need to set $F77FLAGS if you need to define specific user options for Fortran 77 files. You should
normally set the $FORTRANFLAGS variable, which specifies the user-specified options passed to the default Fortran compiler for all Fortran versions.

_F77INCFLAGS
An automatically-generated construction variable containing the Fortran 77 compiler command-line options for specifying directories to be searched for include files. The value of $_F77INCFLAGS is created by appending $INCPREFIX and $INCSUFFIX to the beginning and end of each directory in $F77PATH.

F77PATH
The list of directories that the Fortran 77 compiler will search for include directories. The implicit dependency scanner will search these directories for include files. Don’t explicitly put include directory arguments in $F77FLAGS because the result will be non-portable and the directories will not be searched by the dependency scanner. Note: directory names in $F77PATH will be looked-up relative to the SConscript directory when they are used in a command. To force scons to look-up a directory relative to the root of the source tree use #: You only need to set $F77PATH if you need to define a specific include path for Fortran 77 files. You should normally set the $FORTRANPATH variable, which specifies the include path for the default Fortran compiler for all Fortran versions.

env = Environment(F77PATH='#/include')

The directory look-up can also be forced using the Dir() function:

include = Dir('include')
env = Environment(F77PATH=include)

The directory list will be added to command lines through the automatically-generated $_F77INCFLAGS construction variable, which is constructed by appending the values of the $INCPREFIX and $INCSUFFIX construction variables to the beginning and end of each directory in $F77PATH. Any command lines you define that need the F77PATH directory list should include $_F77INCFLAGS:

env = Environment(F77COM="my_compiler $_F77INCFLAGS -c -o $TARGET $SOURCE")

F77PPCOM
The command line used to compile a Fortran 77 source file to an object file after first running the file through the C preprocessor. Any options specified in the $F77FLAGS and $CPPFLAGS construction variables are included on this command line. You only need to set $F77PPCOM if you need to use a specific C-preprocessor command line for Fortran 77 files. You should normally set the $FORTRANPPCOM variable, which specifies the default C-preprocessor command line for all Fortran versions.

F77PPCOMSTR
The string displayed when a Fortran 77 source file is compiled to an object file after first running the file through the C preprocessor. If this is not set, then $F77PPCOM or $FORTRANPPCOM (the command line) is displayed.
Appendix A. Construction Variables

F77PPFILESUFFIXES
The list of file extensions for which the compilation + preprocessor pass for F77 dialect will be used. By default, this is empty.

F90
The Fortran 90 compiler. You should normally set the $FORTRAN variable, which specifies the default Fortran compiler for all Fortran versions. You only need to set $F90 if you need to use a specific compiler or compiler version for Fortran 90 files.

F90COM
The command line used to compile a Fortran 90 source file to an object file. You only need to set $F90COM if you need to use a specific command line for Fortran 90 files. You should normally set the $FORTRANCOM variable, which specifies the default command line for all Fortran versions.

F90COMSTR
The string displayed when a Fortran 90 source file is compiled to an object file. If this is not set, then $F90COM or $FORTRANCOM (the command line) is displayed.

F90FILESUFFIXES
The list of file extensions for which the F90 dialect will be used. By default, this is [‘.f90’]

F90FLAGS
General user-specified options that are passed to the Fortran 90 compiler. Note that this variable does not contain -I (or similar) include search path options that scons generates automatically from $F90PATH. See $_F90INCFLAGS below, for the variable that expands to those options. You only need to set $F90FLAGS if you need to define specific user options for Fortran 90 files. You should normally set the $FORTRANFLAGS variable, which specifies the user-specified options passed to the default Fortran compiler for all Fortran versions.

_F90INCFLAGS
An automatically-generated construction variable containing the Fortran 90 compiler command-line options for specifying directories to be searched for include files. The value of $_F90INCFLAGS is created by appending $INCPREFIX and $INCSUFFIX to the beginning and end of each directory in $F90PATH.

F90PATH
The list of directories that the Fortran 90 compiler will search for include directories. The implicit dependency scanner will search these directories for include files. Don’t explicitly put include directory arguments in $F90FLAGS because the result will be non-portable and the directories will not be searched by the dependency scanner. Note: directory names in $F90PATH will be looked-up relative to the SConscript directory when they are used in a command. To force scons to look-up a directory relative to the root of the source tree use #: You only need to set $F90PATH if you need to define a specific include path for Fortran 90 files. You should normally set the $FORTRANPATH variable, which specifies the include path for the default Fortran compiler for all Fortran versions.

env = Environment(F90PATH=’#/include’)
Appendix A. Construction Variables

The directory look-up can also be forced using the `Dir()` function:

```plaintext
include = Dir('include')
env = Environment(F90PATH=include)
```

The directory list will be added to command lines through the automatically-generated `$F90INCFLAGS` construction variable, which is constructed by appending the values of the `$INCPREFIX` and `$INCSUFFIX` construction variables to the beginning and end of each directory in `$F90PATH`. Any command lines you define that need the `F90PATH` directory list should include `$F90INCFLAGS`:

```plaintext
env = Environment(F90COM="my_compiler $F90INCFLAGS -c -o $TARGET $SOURCE")
```

**F90PPCOM**

The command line used to compile a Fortran 90 source file to an object file after first running the file through the C preprocessor. Any options specified in the `$F90FLAGS` and `$CPPFLAGS` construction variables are included on this command line. You only need to set `$F90PPCOM` if you need to use a specific C-preprocessor command line for Fortran 90 files. You should normally set the `$FORTRANPPCOM` variable, which specifies the default C-preprocessor command line for all Fortran versions.

**F90PPCOMSTR**

The string displayed when a Fortran 90 source file is compiled after first running the file through the C preprocessor. If this is not set, then `$F90PPCOM` or `$FORTRANPPCOM` (the command line) is displayed.

**F90PPFILESUFFIXES**

The list of file extensions for which the compilation + preprocessor pass for F90 dialect will be used. By default, this is empty

**F95**

The Fortran 95 compiler. You should normally set the `$FORTRAN` variable, which specifies the default Fortran compiler for all Fortran versions. You only need to set `$F95` if you need to use a specific compiler or compiler version for Fortran 95 files.

**F95COM**

The command line used to compile a Fortran 95 source file to an object file. You only need to set `$F95COM` if you need to use a specific command line for Fortran 95 files. You should normally set the `$FORTRANCOM` variable, which specifies the default command line for all Fortran versions.

**F95COMSTR**

The string displayed when a Fortran 95 source file is compiled to an object file. If this is not set, then `$F95COM` or `$FORTRANCOM` (the command line) is displayed.

**F95FILESUFFIXES**

The list of file extensions for which the F95 dialect will be used. By default, this is ` ['.f95']`
Appendix A. Construction Variables

F95FLAGS

General user-specified options that are passed to the Fortran 95 compiler. Note that this variable does not contain `-I` (or similar) include search path options that scons generates automatically from $F95PATH. See $_F95INCFLAGS below, for the variable that expands to those options. You only need to set $F95FLAGS if you need to define specific user options for Fortran 95 files. You should normally set the $FORTRANFLAGS variable, which specifies the user-specified options passed to the default Fortran compiler for all Fortran versions.

_F95INCFLAGS

An automatically-generated construction variable containing the Fortran 95 compiler command-line options for specifying directories to be searched for include files. The value of $_F95INCFLAGS is created by appending $INCPREFIX and $INCSUFFIX to the beginning and end of each directory in $F95PATH.

F95PATH

The list of directories that the Fortran 95 compiler will search for include directories. The implicit dependency scanner will search these directories for include files. Don’t explicitly put include directory arguments in $F95FLAGS because the result will be non-portable and the directories will not be searched by the dependency scanner. Note: directory names in $F95PATH will be looked-up relative to the SConscript directory when they are used in a command. To force scons to look-up a directory relative to the root of the source tree use #: You only need to set $F95PATH if you need to define a specific include path for Fortran 95 files. You should normally set the $FORTRANPATH variable, which specifies the include path for the default Fortran compiler for all Fortran versions.

env = Environment(F95PATH=’#/include’)  

The directory look-up can also be forced using the Dir() function:

include = Dir(‘include’)  
env = Environment(F95PATH=include)

The directory list will be added to command lines through the automatically-generated $_F95INCFLAGS construction variable, which is constructed by appending the values of the $INCPREFIX and $INCSUFFIX construction variables to the beginning and end of each directory in $F95PATH. Any command lines you define that need the F95PATH directory list should include $_F95INCFLAGS:

env = Environment(F95COM="my_compiler $_F95INCFLAGS -c -o $TARGET $SOURCE")

F95PPCOM

The command line used to compile a Fortran 95 source file to an object file after first running the file through the C preprocessor. Any options specified in the $F95FLAGS and $CPPFLAGS construction variables are included on this command line. You only need to set $F95PPCOM if you need to use a specific C-preprocessor command line for Fortran 95 files. You should normally set the $FORTRANPPCOM variable, which specifies the default C-preprocessor command line for all Fortran versions.
Appendix A. Construction Variables

F95PPCOMSTR
The string displayed when a Fortran 95 source file is compiled to an object file after first running the file through the C preprocessor. If this is not set, then $F95PPCOM or $FORTRANPPCOM (the command line) is displayed.

F95PPFILESUFFIXES
The list of file extensions for which the compilation + preprocessor pass for F95 dialect will be used. By default, this is empty.

File
A function that converts a string into a File instance relative to the target being built.

FORTRAN
The default Fortran compiler for all versions of Fortran.

FORTRANCOM
The command line used to compile a Fortran source file to an object file. By default, any options specified in the $FORTRANFLAGS, $CPPFLAGS, $_CPPDEFFLAGS, $_FORTRANMODFLAG, and $_FORTRANINCFLAGS construction variables are included on this command line.

FORTRANCOMSTR
The string displayed when a Fortran source file is compiled to an object file. If this is not set, then $FORTRANCOM (the command line) is displayed.

FORTRANFILESUFFIXES
The list of file extensions for which the FORTRAN dialect will be used. By default, this is [‘.f’, ‘.for’, ‘.ftn’]

FORTRANFLAGS
General user-specified options that are passed to the Fortran compiler. Note that this variable does not contain –I (or similar) include or module search path options that scons generates automatically from $FORTRANPATH. See $_FORTRANINCFLAGS and $_FORTRANMODFLAG, below, for the variables that expand those options.

_FORTRANINCFLAGS
An automatically-generated construction variable containing the Fortran compiler command-line options for specifying directories to be searched for include files and module files. The value of $_FORTRANINCFLAGS is created by prepending/appending $INCPREFIX and $INCSUFFIX to the beginning and end of each directory in $FORTRANPATH.

FORTRANMODDIR
Directory location where the Fortran compiler should place any module files it generates. This variable is empty, by default. Some Fortran compilers will internally append this directory in the search path for module files, as well.
FORTRANMODDIRPREFIX

The prefix used to specify a module directory on the Fortran compiler command line. This will be appended to the beginning of the directory in the $FORTRANMODDIR construction variables when the $FORTRANMODFLAG variables is automatically generated.

FORTRANMODDIRSUFFIX

The suffix used to specify a module directory on the Fortran compiler command line. This will be appended to the beginning of the directory in the $FORTRANMODDIR construction variables when the $FORTRANMODFLAG variables is automatically generated.

_FORTRANMODFLAG

An automatically-generated construction variable containing the Fortran compiler command-line option for specifying the directory location where the Fortran compiler should place any module files that happen to get generated during compilation. The value of $FORTRANMODFLAG is created by prepending/appending $FORTRANMODDIRPREFIX and $FORTRANMODDIRSUFFIX to the beginning and end of the directory in $FORTRANMODDIR.

FORTRANMODPREFIX

The module file prefix used by the Fortran compiler. SCons assumes that the Fortran compiler follows the quasi-standard naming convention for module files of module_name.mod. As a result, this variable is left empty, by default. For situations in which the compiler does not necessarily follow the normal convention, the user may use this variable. Its value will be appended to every module file name as scons attempts to resolve dependencies.

FORTRANMODSUFFIX

The module file suffix used by the Fortran compiler. SCons assumes that the Fortran compiler follows the quasi-standard naming convention for module files of module_name.mod. As a result, this variable is set to ".mod", by default. For situations in which the compiler does not necessarily follow the normal convention, the user may use this variable. Its value will be appended to every module file name as scons attempts to resolve dependencies.

FORTRANPATH

The list of directories that the Fortran compiler will search for include files and (for some compilers) module files. The Fortran implicit dependency scanner will search these directories for include files (but not module files since they are autogenerated and, as such, may not actually exist at the time the scan takes place). Don’t explicitly put include directory arguments in FORTRANFLAGS because the result will be non-portable and the directories will not be searched by the dependency scanner. Note: directory names in FORTRANPATH will be looked-up relative to the SConscript directory when they are used in a command. To force scons to look-up a directory relative to the root of the source tree use #:

```python
env = Environment(FORTRANPATH='#/include')
```

The directory look-up can also be forced using the Dir() function:

```python
include = Dir('include')
env = Environment(FORTRANPATH=include)
```
Appendix A. Construction Variables

The directory list will be added to command lines through the automatically-generated
$_FORTRANINCFLAGS construction variable, which is constructed by appending the values of
the $INCPREFIX and $INCSUFFIX construction variables to the beginning and end of each
directory in $FORTRANPATH. Any command lines you define that need the FORTRANPATH
directory list should include $_FORTRANINCFLAGS:

```
env = Environment(FORTRANCOM="my_compiler $_FORTRANINCFLAGS -c -o $TARGET $SOURCE")
```

FORTRANPPCOM

The command line used to compile a Fortran source file to an object file after first running the file
through the C preprocessor. By default, any options specified in the $FORTRANFLAGS,
$CPPFLAGS, $CPPDEFFLAGS, $_FORTRANMODFLAG, and $_FORTRANINCFLAGS
construction variables are included on this command line.

FORTRANPPCOMSTR

The string displayed when a Fortran source file is compiled to an object file after first running the
file through the C preprocessor. If this is not set, then $FORTRANPPCOM (the command line) is
displayed.

FORTRANPPFILESUFFIXES

The list of file extensions for which the compilation + preprocessor pass for FORTRAN dialect will
be used. By default, this is ['.fpp', '.FPP']

FORTRANSUFFIXES

The list of suffixes of files that will be scanned for Fortran implicit dependencies (INCLUDE lines
and USE statements). The default list is:

```
 ".f77", ".F77", ".f90", ".F90", ".f95", ".F95"]
```

FRAMEWORKPATH

On Mac OS X with gcc, a list containing the paths to search for frameworks. Used by the compiler
to find framework-style includes like #include <Fmwk/Header.h>. Used by the linker to find
user-specified frameworks when linking (see $FRAMEWORKS). For example:

```
env.AppendUnique(FRAMEWORKPATH='myframeworkdir')
```

will add

```
... -Fmyframeworkdir
```

to the compiler and linker command lines.

_FRAMEWORKPATH

On Mac OS X with gcc, an automatically-generated construction variable containing the linker
command-line options corresponding to $FRAMEWORKPATH.
FRAMEWORKPATHPREFIX
On Mac OS X with gcc, the prefix to be used for the FRAMEWORKPATH entries. (see $FRAMEWORKPATH). The default value is -F.

FRAMEWORKPREFIX
On Mac OS X with gcc, the prefix to be used for linking in frameworks (see $FRAMEWORKS). The default value is -framework.

_FRAMEWORKS
On Mac OS X with gcc, an automatically-generated construction variable containing the linker command-line options for linking with FRAMEWORKS.

FRAMEWORKS
On Mac OS X with gcc, a list of the framework names to be linked into a program or shared library or bundle. The default value is the empty list. For example:

env.AppendUnique(FRAMEWORKS=Split('System Cocoa SystemConfiguration'))

FRAMEWORKSFLAGS
On Mac OS X with gcc, general user-supplied frameworks options to be added at the end of a command line building a loadable module. (This has been largely superceded by the $FRAMEWORKPATH, $FRAMEWORKPATHPREFIX, $FRAMEWORKPREFIX and $FRAMEWORKS variables described above.)

GS
The Ghostscript program used to convert PostScript to PDF files.

GSCOM
The Ghostscript command line used to convert PostScript to PDF files.

GSCOMSTR
The string displayed when Ghostscript is used to convert a PostScript file to a PDF file. If this is not set, then $GSCOM (the command line) is displayed.

GSFLAGS
General options passed to the Ghostscript program when converting PostScript to PDF files.

IDLSUFFIXES
The list of suffixes of files that will be scanned for IDL implicit dependencies (#include or import lines). The default list is:

[".idl", ".IDL"]
Appendix A. Construction Variables

IMPLICIT_COMMAND_DEPENDENCIES

Controls whether or not SCons will add implicit dependencies for the commands executed to build targets.

By default, SCons will add to each target an implicit dependency on the command represented by the first argument on any command line it executes. The specific file for the dependency is found by searching the PATH variable in the ENV environment used to execute the command.

If the construction variable $IMPLICIT_COMMAND_DEPENDENCIES is set to a false value (None, False, 0, etc.), then the implicit dependency will not be added to the targets built with that construction environment.

```python
env = Environment(IMPLICIT_COMMAND_DEPENDENCIES = 0)
```

INCPREFIX

The prefix used to specify an include directory on the C compiler command line. This will be appended to the beginning of each directory in the $CPPPATH and $FORTRANPATH construction variables when the $CPPINCFLAGS and $FORTRANINCFLAGS variables are automatically generated.

INCSUFFIX

The suffix used to specify an include directory on the C compiler command line. This will be appended to the end of each directory in the $CPPPATH and $FORTRANPATH construction variables when the $CPPINCFLAGS and $FORTRANINCFLAGS variables are automatically generated.

INSTALL

A function to be called to install a file into a destination file name. The default function copies the file into the destination (and sets the destination file’s mode and permission bits to match the source file’s). The function takes the following arguments:

```python
def install(dest, source, env):
```

`dest` is the path name of the destination file. `source` is the path name of the source file. `env` is the construction environment (a dictionary of construction values) in force for this file installation.

INSTALLSTR

The string displayed when a file is installed into a destination file name. The default is:

```
Install file: "$SOURCE" as "$TARGET"
```

INTEL_C_COMPILER_VERSION

Set by the "intelc" Tool to the major version number of the Intel C compiler selected for use.

JAR

The Java archive tool.
Appendix A. Construction Variables

JARCHDIR
The directory to which the Java archive tool should change (using the \(-c\) option).

JARCOM
The command line used to call the Java archive tool.

JARCOMSTR
The string displayed when the Java archive tool is called. If this is not set, then $JARCOM (the command line) is displayed.

env = Environment(JARCOMSTR = "JARchiving $SOURCES into $TARGET")

JARFLAGS
General options passed to the Java archive tool. By default this is set to cf to create the necessary jar file.

JARSUFFIX
The suffix for Java archives: .jar by default.

JAVABOOTCLASSPATH
Specifies the list of directories that will be added to the javac command line via the \(-bootclasspath\) option. The individual directory names will be separated by the operating system’s path separate character (: on UNIX/Linux/POSIX, ; on Windows).

JAVAC
The Java compiler.

JAVACOM
The command line used to compile a directory tree containing Java source files to corresponding Java class files. Any options specified in the $JAVACFLAGS construction variable are included on this command line.

JAVACOMSTR
The string displayed when compiling a directory tree of Java source files to corresponding Java class files. If this is not set, then $JAVACOM (the command line) is displayed.

env = Environment(JAVACOMSTR = "Compiling class files $TARGETS from $SOURCES")

JAVACFLAGS
General options that are passed to the Java compiler.

JAVACLASSDIR
The directory in which Java class files may be found. This is stripped from the beginning of any Java .class file names supplied to the JavaH builder.
Appendix A. Construction Variables

JAVACLASSPATH
Specifies the list of directories that will be searched for Java .class file. The directories in this list will be added to the javac and javah command lines via the -classpath option. The individual directory names will be separated by the operating system’s path separate character (; on UNIX/Linux/POSIX, ; on Windows).

Note that this currently just adds the specified directory via the -classpath option. SCons does not currently search the $JAVACLASSPATH directories for dependency .class files.

JAVACLASSSUFFIX
The suffix for Java class files; .class by default.

JAVAH
The Java generator for C header and stub files.

JAVAHCOM
The command line used to generate C header and stub files from Java classes. Any options specified in the $JAVAHFLAGS construction variable are included on this command line.

JAVAHCOMSTR
The string displayed when C header and stub files are generated from Java classes. If this is not set, then $JAVAHCOM (the command line) is displayed.

env = Environment(JAVAHCOMSTR = "Generating header/stub file(s) $TARGETS from $SOURCES")

JAVAHFLAGS
General options passed to the C header and stub file generator for Java classes.

JAVASOURCEPATH
Specifies the list of directories that will be searched for input .java file. The directories in this list will be added to the javac command line via the -sourcepath option. The individual directory names will be separated by the operating system’s path separate character (; on UNIX/Linux/POSIX, ; on Windows).

Note that this currently just adds the specified directory via the -sourcepath option. SCons does not currently search the $JAVASOURCEPATH directories for dependency .java files.

JAVASUFFIX
The suffix for Java files; .java by default.

JAVAVERSION
Specifies the Java version being used by the Java builder. This is not currently used to select one version of the Java compiler vs. another. Instead, you should set this to specify the version of Java supported by your javac compiler. The default is 1.4.
This is sometimes necessary because Java 1.5 changed the file names that are created for nested anonymous inner classes, which can cause a mismatch with the files that SCons expects will be generated by the javac compiler. Setting $JAVAVERSION to 1.5 (or 1.6, as appropriate) can make SCons realize that a Java 1.5 or 1.6 build is actually up to date.

LATEX
The LaTeX structured formatter and typesetter.

LATEXCOM
The command line used to call the LaTeX structured formatter and typesetter.

LATEXCOMSTR
The string displayed when calling the LaTeX structured formatter and typesetter. If this is not set, then $LATEXCOM (the command line) is displayed.

env = Environment(LATEXCOMSTR = "Building $TARGET from LaTeX input $SOURCES")

LATEXFLAGS
General options passed to the LaTeX structured formatter and typesetter.

LATEXRETRIES
The maximum number of times that LaTeX will be re-run if the .log generated by the $LATEXCOM command indicates that there are undefined references. The default is to try to resolve undefined references by re-running LaTeX up to three times.

LATEXSUFFIXES
The list of suffixes of files that will be scanned for LaTeX implicit dependencies (\include or \import files). The default list is:

[".tex", ".ltx", ".latex"]

LDMODULE
The linker for building loadable modules. By default, this is the same as $SHLINK.

LDMODULECOM
The command line for building loadable modules. On Mac OS X, this uses the $LDMODULE, $LDMODULEFLAGS and $FRAMEWORKSFLAGS variables. On other systems, this is the same as $SHLINK.

LDMODULECOMSTR
The string displayed when building loadable modules. If this is not set, then $LDMODULECOM (the command line) is displayed.

LDMODULEFLAGS
General user options passed to the linker for building loadable modules.
## Appendix A. Construction Variables

### LDMODULEPREFIX
The prefix used for loadable module file names. On Mac OS X, this is null; on other systems, this is the same as $SHLIBPREFIX.

### LDMODULESUFFIX
The suffix used for loadable module file names. On Mac OS X, this is null; on other systems, this is the same as $SHLIBSUFFIX.

### LEX
The lexical analyzer generator.

### LEXCOM
The command line used to call the lexical analyzer generator to generate a source file.

### LEXCOMSTR
The string displayed when generating a source file using the lexical analyzer generator. If this is not set, then $LEXCOM (the command line) is displayed.

```python
e = Environment(LEXCOMSTR = "Lex'ing $TARGET from $SOURCES")
```

### LEXFLAGS
General options passed to the lexical analyzer generator.

### _LIBDIRFLAGS
An automatically-generated construction variable containing the linker command-line options for specifying directories to be searched for library. The value of $_LIBDIRFLAGS is created by appending $LIBDIRPREFIX and $LIBDIRSUFFIX to the beginning and end of each directory in $LIBPATH.

### LIBDIRPREFIX
The prefix used to specify a library directory on the linker command line. This will be appended to the beginning of each directory in the $LIBPATH construction variable when the $_LIBDIRFLAGS variable is automatically generated.

### LIBDIRSUFFIX
The suffix used to specify a library directory on the linker command line. This will be appended to the end of each directory in the $LIBPATH construction variable when the $_LIBDIRFLAGS variable is automatically generated.

### _LIBFLAGS
An automatically-generated construction variable containing the linker command-line options for specifying libraries to be linked with the resulting target. The value of $_LIBFLAGS is created by appending $LIBLINKPREFIX and $LIBLINKSUFFIX to the beginning and end of each filename in $LIBS.
LIBLINKPREFIX

The prefix used to specify a library to link on the linker command line. This will be appended to the
beginning of each library in the $LIBS construction variable when the $_LIBFLAGS variable is
automatically generated.

LIBLINKSUFFIX

The suffix used to specify a library to link on the linker command line. This will be appended to the
end of each library in the $LIBS construction variable when the $_LIBFLAGS variable is
automatically generated.

LIBPATH

The list of directories that will be searched for libraries. The implicit dependency scanner will
search these directories for include files. Don’t explicitly put include directory arguments in
$LINKFLAGS or $SHLINKFLAGS because the result will be non-portable and the directories will
not be searched by the dependency scanner. Note: directory names in LIBPATH will be looked-up
relative to the SConscript directory when they are used in a command. To force scons to look-up a
directory relative to the root of the source tree use #:

```python
env = Environment(LIBPATH='#/libs')
```

The directory look-up can also be forced using the Dir() function:

```python
libs = Dir('libs')
env = Environment(LIBPATH=libs)
```

The directory list will be added to command lines through the automatically-generated
$_LIBDIRFLAGS construction variable, which is constructed by appending the values of the
$LIBDIPREFIX and $LIBDIRSUFFIX construction variables to the beginning and end of each
directory in LIBPATH. Any command lines you define that need the LIBPATH directory list
should include $_LIBDIRFLAGS:

```python
env = Environment(LINKCOM="my_linker $_LIBDIRFLAGS $_LIBFLAGS -o $TARGET $SOURCE")
```

LIBPREFIX

The prefix used for (static) library file names. A default value is set for each platform (posix, win32,
os2, etc.), but the value is overridden by individual tools (ar, mslib, sgiar, sunar, tlib, etc.) to reflect
the names of the libraries they create.

LIBPREFIXES

A list of all legal prefixes for library file names. When searching for library dependencies, SCons
will look for files with these prefixes, the base library name, and suffixes in the $LIBSUFFIXES list.

LIBS

A list of one or more libraries that will be linked with any executable programs created by this
environment.
The library list will be added to command lines through the automatically-generated $_LIBFLAGS
construction variable, which is constructed by appending the values of the $LIBLINKPREFIX and
$LIBLINKSUFFIX construction variables to the beginning and end of each filename in $LIBS. Any
command lines you define that need the LIBS library list should include $_LIBFLAGS:

```
env = Environment(LINKCOM="my_linker $_LIBDIRFLAGS $_LIBFLAGS -o $TARGET $SOURCE")
```

If you add a File object to the $LIBS list, the name of that file will be added to $_LIBFLAGS, and
thus the link line, as is, without $LIBLINKPREFIX or $LIBLINKSUFFIX. For example:
```
env.Append(LIBS=File('/tmp/mylib.so'))
```

In all cases, scons will add dependencies from the executable program to all the libraries in this list.

**LIBSUFFIX**

The suffix used for (static) library file names. A default value is set for each platform (posix, win32,
os2, etc.), but the value is overridden by individual tools (ar, mslib, sgiar, sunar, tlib, etc.) to reflect
the names of the libraries they create.

**LIBSUFFIXES**

A list of all legal suffixes for library file names. When searching for library dependencies, SCons
will look for files with prefixes, in the $LIBPREFIXES list, the base library name, and these
suffixes.

**LICENSE**

The abbreviated name of the license under which this project is released (gpl, lpgl, bsd etc.). See
http://www.opensource.org/licenses/alphabetical for a list of license names.

**LINK**

The linker.

**LINKCOM**

The command line used to link object files into an executable.

**LINKCOMSTR**

The string displayed when object files are linked into an executable. If this is not set, then
$LINKCOM (the command line) is displayed.
```
env = Environment(LINKCOMSTR = "Linking $TARGET")
```

**LINKFLAGS**

General user options passed to the linker. Note that this variable should not contain \(-l\) (or similar)
options for linking with the libraries listed in $LIBS, nor \(-L\) (or similar) library search path options
that scons generates automatically from $LIBPATH. See $_LIBFLAGS above, for the variable that
expands to library-link options, and $_LIBDIRFLAGS above, for the variable that expands to
library search path options.
Appendix A. Construction Variables

M4
The M4 macro preprocessor.

M4COM
The command line used to pass files through the M4 macro preprocessor.

M4COMSTR
The string displayed when a file is passed through the M4 macro preprocessor. If this is not set, then $M4COM (the command line) is displayed.

M4FLAGS
General options passed to the M4 macro preprocessor.

MAKEINDEX
The makeindex generator for the TeX formatter and typesetter and the LaTeX structured formatter and typesetter.

MAKEINDEXCOM
The command line used to call the makeindex generator for the TeX formatter and typesetter and the LaTeX structured formatter and typesetter.

MAKEINDEXCOMSTR
The string displayed when calling the makeindex generator for the TeX formatter and typesetter and the LaTeX structured formatter and typesetter. If this is not set, then $MAKEINDEXCOM (the command line) is displayed.

MAKEINDEXFLAGS
General options passed to the makeindex generator for the TeX formatter and typesetter and the LaTeX structured formatter and typesetter.

MAXLINELENGTH
The maximum number of characters allowed on an external command line. On Win32 systems, link lines longer than this many characters are linked via a temporary file name.

MIDL
The Microsoft IDL compiler.

MIDLCOM
The command line used to pass files to the Microsoft IDL compiler.

MIDLCOMSTR
The string displayed when the Microsoft IDL copmiler is called. If this is not set, then $MIDLCOM (the command line) is displayed.

MIDLFLAGS
General options passed to the Microsoft IDL compiler.
Appendix A. Construction Variables

MSVS

When the Microsoft Visual Studio tools are initialized, they set up this dictionary with the following keys:

VERSION: the version of MSVS being used (can be set via MSVS_VERSION)

VERSIONS: the available versions of MSVS installed

VCINSTALLDIR: installed directory of Visual C++

VSINSTALLDIR: installed directory of Visual Studio

FRAMEWORKDIR: installed directory of the .NET framework

FRAMEWORKVERSIONS: list of installed versions of the .NET framework, sorted latest to oldest.

FRAMEWORKVERSION: latest installed version of the .NET framework

FRAMEWORKSDKDIR: installed location of the .NET SDK.

PLATFORMSDKDIR: installed location of the Platform SDK.

PLATFORMSDK_MODULES: dictionary of installed Platform SDK modules, where the dictionary keys are keywords for the various modules, and the values are 2-tuples where the first is the release date, and the second is the version number.

If a value isn’t set, it wasn’t available in the registry.

MSVS_IGNORE_IDE_PATHS

Tells the MS Visual Studio tools to use minimal INCLUDE, LIB, and PATH settings, instead of the settings from the IDE.

For Visual Studio, SCons will (by default) automatically determine where MSVS is installed, and use the LIB, INCLUDE, and PATH variables set by the IDE. You can override this behavior by setting these variables after Environment initialization, or by setting MSVS_IGNORE_IDE_PATHS = 1 in the Environment initialization. Specifying this will not leave these unset, but will set them to a minimal set of paths needed to run the tools successfully.

For VS6, the minimal set is:
Appendix A. Construction Variables

INCLUDE:’<VSDir>\VC98\ATL\include;<VSDir>\VC98\MFC\include;<VSDir>\VC98\include’
LIB:’<VSDir>\VC98\MFC\lib;<VSDir>\VC98\lib’
PATH:’<VSDir>\Common\MSDev98\bin;<VSDir>\VC98\bin’

For VS7, it is:

INCLUDE:’<VSDir>\Vc7\atlmfc\include;<VSDir>\Vc7\include’
LIB:’<VSDir>\Vc7\atlmfc\lib;<VSDir>\Vc7\lib’
PATH:’<VSDir>\Common7\Tools\bin;<VSDir>\Common7\Tools;<VSDir>\Vc7\bin’

Where ’<VSDir>’ is the installed location of Visual Studio.

MSVS_PROJECT_BASE_PATH

The string placed in a generated Microsoft Visual Studio solution file as the value of the
SccProjectFilePathRelativizedFromConnection0 and
SccProjectFilePathRelativizedFromConnection1 attributes of the
GlobalSection(SourceCodeControl) section. There is no default value.

MSVS_PROJECT_GUID

The string placed in a generated Microsoft Visual Studio project file as the value of the
ProjectGUID attribute. The string is also placed in the SolutionUniqueID attribute of the
GlobalSection(SourceCodeControl) section of the Microsoft Visual Studio solution file.
There is no default value.

MSVS_SCC_AUX_PATH

The path name placed in a generated Microsoft Visual Studio project file as the value of the
SccAuxPath attribute if the MSVS_SCC_PROVIDER construction variable is also set. There is no
default value.

MSVS_SCC_LOCAL_PATH

The path name placed in a generated Microsoft Visual Studio project file as the value of the
SccLocalPath attribute if the MSVS_SCC_PROVIDER construction variable is also set. The path
name is also placed in the SccLocalPath0 and SccLocalPath1 attributes of the
GlobalSection(SourceCodeControl) section of the Microsoft Visual Studio solution file.
There is no default value.

MSVS_SCC_PROJECT_NAME

The project name placed in a generated Microsoft Visual Studio project file as the value of the
SccProjectName attribute. There is no default value.

MSVS_SCC_PROVIDER

The string placed in a generated Microsoft Visual Studio project file as the value of the
SccProvider attribute. The string is also placed in the SccProvider1 attribute of the
GlobalSection(SourceCodeControl) section of the Microsoft Visual Studio solution file.
There is no default value.
Appendix A. Construction Variables

MSVS_USE_MFC_DIRS
Tells the MS Visual Studio tool(s) to use the MFC directories in its default paths for compiling and linking. The $MSVS_USE_MFC_DIRS variable has no effect if the INCLUDE or LIB environment variables are set explicitly.

Under Visual Studio version 6, setting $MSVS_USE_MFC_DIRS to a non-zero value adds the ATL\include and MFC\include directories to the default INCLUDE external environment variable, and adds the MFC\lib directory to the default LIB external environment variable.

Under Visual Studio version 7, setting $MSVS_USE_MFC_DIRS to a non-zero value adds the atlmfc\include directory to the default INCLUDE external environment variable, and adds the atlmfc\lib directory to the default LIB external environment variable.

Under Visual Studio version 8, setting $MSVS_USE_MFC_DIRS to a non-zero value will, by default, add the atlmfc\include directory to the default INCLUDE external environment variable, and the atlmfc\lib directory to the default LIB external environment variable. If, however, the ['MSVS'] ['PLATFORMSDKDIR'] variable is set, then the mfc and the atl subdirectories of the PLATFORMSDKDIR are added to the default value of the INCLUDE external environment variable, and the default value of the LIB external environment variable is left untouched.

MSVS_VERSION
Sets the preferred version of MSVS to use.

SCons will (by default) select the latest version of MSVS installed on your machine. So, if you have version 6 and version 7 (MSVS .NET) installed, it will prefer version 7. You can override this by specifying the MSVS_VERSION variable in the Environment initialization, setting it to the appropriate version ('6.0' or '7.0', for example). If the given version isn’t installed, tool initialization will fail.

MSVSBUILDCOM
The build command line placed in a generated Microsoft Visual Studio project file. The default is to have Visual Studio invoke SCons with any specified build targets.

MSVSCLEANCOM
The clean command line placed in a generated Microsoft Visual Studio project file. The default is to have Visual Studio invoke SCons with the -c option to remove any specified targets.

MSVSENCODING
The encoding string placed in a generated Microsoft Visual Studio project file. The default is encoding Windows-1252.
Appendix A. Construction Variables

MSVSPROJECTCOM
The action used to generate Microsoft Visual Studio project files.

MSVSPROJECTSUFFIX
The suffix used for Microsoft Visual Studio project (DSP) files. The default value is .vcproj when using Visual Studio version 7.x (.NET) or later version, and .dsp when using earlier versions of Visual Studio.

MSVSREBUILDCOM
The rebuild command line placed in a generated Microsoft Visual Studio project file. The default is to have Visual Studio invoke SCons with any specified rebuild targets.

MSVSSCONS
The SCons used in generated Microsoft Visual Studio project files. The default is the version of SCons being used to generate the project file.

MSVSSCONSCOM
The default SCons command used in generated Microsoft Visual Studio project files.

MSVSSCONSCRIPT
The sconscript file (that is, SConstruct or SConscript file) that will be invoked by Visual Studio project files (through the $MSVSSCONSCOM variable). The default is the same sconscript file that contains the call to MSVSProject to build the project file.

MSVSSCONSFAGS
The SCons flags used in generated Microsoft Visual Studio project files.

MSVSSOLUTIONCOM
The action used to generate Microsoft Visual Studio solution files.

MSVSSOLUTIONSUFFIX
The suffix used for Microsoft Visual Studio solution (DSW) files. The default value is .sln when using Visual Studio version 7.x (.NET), and .dsw when using earlier versions of Visual Studio.

MWCW_VERSION
The version number of the MetroWerks CodeWarrior C compiler to be used.

MWCW_VERSIONS
A list of installed versions of the MetroWerks CodeWarrior C compiler on this system.

NAME
Specifies the name of the project to package.
Appendix A. Construction Variables

no_import_lib
When set to non-zero, suppresses creation of a corresponding Windows static import lib by the SharedLibrary builder when used with MinGW, Microsoft Visual Studio or Metrowerks. This also suppresses creation of an export (.exp) file when using Microsoft Visual Studio.

OBJPREFIX
The prefix used for (static) object file names.

OBJSUFX
The suffix used for (static) object file names.

P4
The Perforce executable.

P4COM
The command line used to fetch source files from Perforce.

P4COMSTR
The string displayed when fetching a source file from Perforce. If this is not set, then $P4COM (the command line) is displayed.

P4FLAGS
General options that are passed to Perforce.

PACKAGEROOT
Specifies the directory where all files in resulting archive will be placed if applicable. The default value is "$NAME-$VERSION".

PACKAGETYPE
Selects the package type to build. Currently these are available:

* msi - Microsoft Installer
* rpm - Redhat Package Manger
* ipkg - Itsy Package Management System
* tarbz2 - compressed tar
* targa - compressed tar
* zip - zip file
* src_tarbz2 - compressed tar source
* src_targa - compressed tar source
* src_zip - zip file source

This may be overridden with the "package_type" command line option.

PACKAGEVERSION
The version of the package (not the underlying project). This is currently only used by the rpm packager and should reflect changes in the packaging, not the underlying project code itself.

PCH
The Microsoft Visual C++ precompiled header that will be used when compiling object files. This variable is ignored by tools other than Microsoft Visual C++. When this variable is defined SCons
Appendix A. Construction Variables

will add options to the compiler command line to cause it to use the precompiled header, and will also set up the dependencies for the PCH file. Example:

```python
env[‘PCH’] = ’StdAfx.pch’
```

**PCHCOM**

The command line used by the PCH builder to generated a precompiled header.

**PCHCOMSTR**

The string displayed when generating a precompiled header. If this is not set, then $PCHCOM (the command line) is displayed.

**PCHPDBFLAGS**

A construction variable that, when expanded, adds the `/yD` flag to the command line only if the $PDB construction variable is set.

**PCHSTOP**

This variable specifies how much of a source file is precompiled. This variable is ignored by tools other than Microsoft Visual C++, or when the PCH variable is not being used. When this variable is define it must be a string that is the name of the header that is included at the end of the precompiled portion of the source files, or the empty string if the "#pragma hrdstop" construct is being used:

```python
env[‘PCHSTOP’] = ’StdAfx.h’
```

**PDB**

The Microsoft Visual C++ PDB file that will store debugging information for object files, shared libraries, and programs. This variable is ignored by tools other than Microsoft Visual C++. When this variable is defined SCons will add options to the compiler and linker command line to cause them to generate external debugging information, and will also set up the dependencies for the PDB file. Example:

```python
env[‘PDB’] = ’hello.pdb’
```

The Visual C++ compiler switch that SCons uses by default to generate PDB information is `/Z7`. This works correctly with parallel (-j) builds because it embeds the debug information in the intermediate object files, as opposed to sharing a single PDB file between multiple object files. This is also the only way to get debug information embedded into a static library. Using the `/Zi` instead may yield improved link-time performance, although parallel builds will no longer work. You can generate PDB files with the `/Zi` switch by overriding the default SCCPDBFLAGS variable; see the entry for that variable for specific examples.

**PDFCOM**

A deprecated synonym for $DVIPDFCOM.

**PDFLATEX**

The pdflatex utility.
Appendix A. Construction Variables

PDFLATEXCOM
The command line used to call the pdflatex utility.

PDFLATEXCOMSTR
The string displayed when calling the pdflatex utility. If this is not set, then \$PDFLATEXCOM (the command line) is displayed.

    env = Environment(PDFLATEXCOMSTR = "Building $TARGET from LaTeX input $SOURCES")

PDFLATEXFLAGS
General options passed to the pdflatex utility.

PDFPREFIX
The prefix used for PDF file names.

PDFSUFFIX
The suffix used for PDF file names.

PDFTEX
The pdftex utility.

PDFTEXCOM
The command line used to call the pdftex utility.

PDFTEXCOMSTR
The string displayed when calling the pdftex utility. If this is not set, then \$PDFTEXCOM (the command line) is displayed.

    env = Environment(PDFTEXCOMSTR = "Building $TARGET from TeX input $SOURCES")

PDFTEXFLAGS
General options passed to the pdftex utility.

PKGCHK
On Solaris systems, the package-checking program that will be used (along with \$PKGINFO) to look for installed versions of the Sun PRO C++ compiler. The default is /usr/sbin/pgkchk.

PKGINFO
On Solaris systems, the package information program that will be used (along with \$PKGCHK) to look for installed versions of the Sun PRO C++ compiler. The default is pkginfo.

PLATFORM
The name of the platform used to create the Environment. If no platform is specified when the Environment is created, scons autodetects the platform.

    env = Environment(tools = [])
    if env['PLATFORM'] == 'cygwin':
        Tool('mingw')(env)
else:
    Tool('msvc')(env)

PRINT_CMD_LINE_FUNC

A Python function used to print the command lines as they are executed (assuming command
printing is not disabled by the -q or -s options or their equivalents). The function should take four
arguments: s, the command being executed (a string), target, the target being built (file node, list,
or string name(s)), source, the source(s) used (file node, list, or string name(s)), and env, the
environment being used.

The function must do the printing itself. The default implementation, used if this variable is not set
or is None, is:

def print_cmd_line(s, target, source, env):
    sys.stdout.write(s + "\n")

Here’s an example of a more interesting function:

def print_cmd_line(s, target, source, env):
    sys.stdout.write("Building %s -> %s...\n" %
            (" and ".join([str(x) for x in source]),
            " and ".join([str(x) for x in target])))
    env=Environment(PRINT_CMD_LINE_FUNC=print_cmd_line)
    env.Program('foo', 'foo.c')

    This just prints "Building targetname from sourcename..." instead of the actual commands.
    Such a function could also log the actual commands to a log file, for example.

PROGPREFIX

The prefix used for executable file names.

PROGSUFFIX

The suffix used for executable file names.

PSCOM

The command line used to convert TeX DVI files into a PostScript file.

PSCOMSTR

The string displayed when a TeX DVI file is converted into a PostScript file. If this is not set, then
SPSCOM (the command line) is displayed.

PSPREFIX

The prefix used for PostScript file names.

PSSUFFIX

The prefix used for PostScript file names.
Appendix A. Construction Variables

QT_AUTOSCAN
Turn off scanning for mocable files. Use the Moc Builder to explicitly specify files to run moc on.

QT_BINPATH
The path where the qt binaries are installed. The default value is '$QTDIR/bin'.

QT_CPPPATH
The path where the qt header files are installed. The default value is '$QTDIR/include'. Note: If you set this variable to None, the tool won’t change the $CPPPATH construction variable.

QT_DEBUG
Prints lots of debugging information while scanning for moc files.

QT_LIB
Default value is ‘qt’. You may want to set this to ‘qt-mt’. Note: If you set this variable to None, the tool won’t change the $LIBS variable.

QT_LIBPATH
The path where the qt libraries are installed. The default value is '$QTDIR/lib'. Note: If you set this variable to None, the tool won’t change the $LIBPATH construction variable.

QT_MOC
Default value is '$QT_BINPATH/moc'.

QT_MOCXXPREFIX
Default value is ”. Prefix for moc output files, when source is a cxx file.

QT_MOCXXSUFFIX
Default value is ‘.moc’. Suffix for moc output files, when source is a cxx file.

QT_MOCFROMCXXCOM
Command to generate a moc file from a cpp file.

QT_MOCFROMCXXCOMSTR
The string displayed when generating a moc file from a cpp file. If this is not set, then $QT_MOCFROMCXXCOM (the command line) is displayed.

QT_MOCFROMCXXFLAGS
Default value is ‘-i’. These flags are passed to moc, when moccing a C++ file.

QT_MOCFROMHCOM
Command to generate a moc file from a header.
Appendix A. Construction Variables

QT_MOCFROMHCOMSTR
The string displayed when generating a moc file from a cpp file. If this is not set, then
SQT_MOCFROMHCOM (the command line) is displayed.

QT_MOCFROMHFLAGS
Default value is "". These flags are passed to moc, when moccing a header file.

QT_MOCHPREFIX
Default value is 'moc_'. Prefix for moc output files, when source is a header.

QT_MOCHSUFFIX
Default value is 'SCXXFILESUFFIX'. Suffix for moc output files, when source is a header.

QT_UIC
Default value is '$QT_BINPATH/uic'.

QT_UICCOM
Command to generate header files from .ui files.

QT_UICCOMSTR
The string displayed when generating header files from .ui files. If this is not set, then
SQT_UICCOM (the command line) is displayed.

QT_UICDECLFLAGS
Default value is "". These flags are passed to uic, when creating a.h file from a .ui file.

QT_UICDECLPREFIX
Default value is "". Prefix for uic generated header files.

QT_UICDECLSUFFIX
Default value is '.h'. Suffix for uic generated header files.

QT_UICIMPLFLAGS
Default value is "". These flags are passed to uic, when creating a cxx file from a .ui file.

QT_UICIMPLPREFIX
Default value is 'uic_'. Prefix for uic generated implementation files.

QT_UICIMPLSUFFIX
Default value is 'SCXXFILESUFFIX'. Suffix for uic generated implementation files.

QT_UISUFFIX
Default value is '.ui'. Suffix of designer input files.
Appendix A. Construction Variables

QTDIR

The qt tool tries to take this from os.environ. It also initializes all QT_* construction variables listed below. (Note that all paths are constructed with python’s os.path.join() method, but are listed here with the ‘/’ separator for easier reading.) In addition, the construction environment variables $CPPPATH, $LIBPATH and $LIBS may be modified and the variables PROGEMITTER, SHLIBEMITTER and LIBEMITTER are modified. Because the build-performance is affected when using this tool, you have to explicitly specify it at Environment creation:

Environment(tools=['default', 'qt'])

The qt tool supports the following operations:

Automatic moc file generation from header files. You do not have to specify moc files explicitly, the tool does it for you. However, there are a few preconditions to do so: Your header file must have the same filebase as your implementation file and must stay in the same directory. It must have one of the suffixes .h, .hpp, .H, .hxx, .hh. You can turn off automatic moc file generation by setting QT_AUTOSCAN to 0. See also the corresponding builder method .B Moc()

Automatic moc file generation from cxx files. As stated in the qt documentation, include the moc file at the end of the cxx file. Note that you have to include the file, which is generated by the transformation ${QT_MOCXXPREFIX}<basename>${QT_MOCXXSUFFIX}, by default <basename>.moc. A warning is generated after building the moc file, if you do not include the correct file. If you are using VariantDir, you may need to specify duplicate=1. You can turn off automatic moc file generation by setting QT_AUTOSCAN to 0. See also the corresponding Moc builder method.

Automatic handling of .ui files. The implementation files generated from .ui files are handled much the same as yacc or lex files. Each .ui file given as a source of Program, Library or SharedLibrary will generate three files, the declaration file, the implementation file and a moc file. Because there are also generated headers, you may need to specify duplicate=1 in calls to VariantDir. See also the corresponding Uic builder method.

RANLIB

The archive indexer.

RANLIBCOM

The command line used to index a static library archive.

RANLIBCOMSTR

The string displayed when a static library archive is indexed. If this is not set, then $RANLIBCOM (the command line) is displayed.

env = Environment(RANLIBCOMSTR = "Indexing $TARGET")
Appendix A. Construction Variables

RANLIBFLAGS
General options passed to the archive indexer.

RC
The resource compiler used to build a Microsoft Visual C++ resource file.

RCCOM
The command line used to build a Microsoft Visual C++ resource file.

RCCOMSTR
The string displayed when invoking the resource compiler to build a Microsoft Visual C++ resource file. If this is not set, then $RCCOM (the command line) is displayed.

RCFLAGS
The flags passed to the resource compiler by the RES builder.

RCINCFLAGS
An automatically-generated construction variable containing the command-line options for specifying directories to be searched by the resource compiler. The value of $RCINCFLAGS is created by appending $RCINCPREFIX and $RCINCSUFFIX to the beginning and end of each directory in $CPPPATH.

RCINCPREFIX
The prefix (flag) used to specify an include directory on the resource compiler command line. This will be appended to the beginning of each directory in the $CPPPATH construction variable when the $RCINCFLAGS variable is expanded.

RCINCSUFFIX
The suffix used to specify an include directory on the resource compiler command line. This will be appended to the end of each directory in the $CPPPATH construction variable when the $RCINCFLAGS variable is expanded.

RCS
The RCS executable. Note that this variable is not actually used for the command to fetch source files from RCS; see the $RCS_CO construction variable, below.

RCS_CO
The RCS "checkout" executable, used to fetch source files from RCS.

RCS_COCOM
The command line used to fetch (checkout) source files from RCS.

RCS_COCOMSTR
The string displayed when fetching a source file from RCS. If this is not set, then $RCS_COCOM (the command line) is displayed.
Appendix A. Construction Variables

RCS_COFLAGS
  Options that are passed to the $RCS_CO command.

RDirs
  A function that converts a string into a list of Dir instances by searching the repositories.

REGSVR
  The program used on Windows systems to register a newly-built DLL library whenever the
  SharedLibrary builder is passed a keyword argument of register=1.

REGSVRCOM
  The command line used on Windows systems to register a newly-built DLL library whenever the
  SharedLibrary builder is passed a keyword argument of register=1.

REGSVRCOMSTR
  The string displayed when registering a newly-built DLL file. If this is not set, then
  $REGSVRCOM (the command line) is displayed.

REGSVRFLAGS
  Flags passed to the DLL registration program on Windows systems when a newly-built DLL library
  is registered. By default, this includes the /s that prevents dialog boxes from popping up and
  requiring user attention.

RMIC
  The Java RMI stub compiler.

RMICCOM
  The command line used to compile stub and skeleton class files from Java classes that contain RMI
  implementations. Any options specified in the $RMICFLAGS construction variable are included on
  this command line.

RMICCOMSTR
  The string displayed when compiling stub and skeleton class files from Java classes that contain
  RMI implementations. If this is not set, then $RMICCOM (the command line) is displayed.

   env = Environment(RMICCOMSTR = "Generating stub/skeleton class files $TARGETS from $SOURCES")

RMICFLAGS
  General options passed to the Java RMI stub compiler.

_RPATH
  An automatically-generated construction variable containing the rpath flags to be used when linking
  a program with shared libraries. The value of $_RPATH is created by appending $RPATHPREFIX
  and $RPATHSUFFIX to the beginning and end of each directory in $RPATH.
Appendix A. Construction Variables

RPATH
A list of paths to search for shared libraries when running programs. Currently only used in the GNU (gnulink), IRIX (sgilink) and Sun (sunlink) linkers. Ignored on platforms and toolchains that don’t support it. Note that the paths added to RPATH are not transformed by scons in any way: if you want an absolute path, you must make it absolute yourself.

RPATHPREFIX
The prefix used to specify a directory to be searched for shared libraries when running programs. This will be appended to the beginning of each directory in the $RPATH construction variable when the $_RPATH variable is automatically generated.

RPATHSUFFIX
The suffix used to specify a directory to be searched for shared libraries when running programs. This will be appended to the end of each directory in the $RPATH construction variable when the $_RPATH variable is automatically generated.

RPCGEN
The RPC protocol compiler.

RPCGENCLIENTFLAGS
Options passed to the RPC protocol compiler when generating client side stubs. These are in addition to any flags specified in the $RPCGENFLAGS construction variable.

RPCGENFLAGS
General options passed to the RPC protocol compiler.

RPCGENHEADERFLAGS
Options passed to the RPC protocol compiler when generating a header file. These are in addition to any flags specified in the $RPCGENFLAGS construction variable.

RPCGENSERVICEFLAGS
Options passed to the RPC protocol compiler when generating server side stubs. These are in addition to any flags specified in the $RPCGENFLAGS construction variable.

RPCGENXDRFLAGS
Options passed to the RPC protocol compiler when generating XDR routines. These are in addition to any flags specified in the $RPCGENFLAGS construction variable.

SCANNERS
A list of the available implicit dependency scanners. New file scanners may be added by appending to this list, although the more flexible approach is to associate scanners with a specific Builder. See the sections "Builder Objects" and "Scanner Objects," below, for more information.

SCCS
The SCCS executable.
Appendix A. Construction Variables

SCCSCOM
The command line used to fetch source files from SCCS.

SCCSCOMSTR
The string displayed when fetching a source file from a CVS repository. If this is not set, then $SCCSCOM (the command line) is displayed.

SCCSFLAGS
General options that are passed to SCCS.

SCCSGETFLAGS
Options that are passed specifically to the SCCS "get" subcommand. This can be set, for example, to \(-e\) to check out editable files from SCCS.

SCONS_HOME
The (optional) path to the SCons library directory, initialized from the external environment. If set, this is used to construct a shorter and more efficient search path in the $MSVSSCONS command line executed from Microsoft Visual Studio project files.

SHCC
The C compiler used for generating shared-library objects.

SHCCCOM
The command line used to compile a C source file to a shared-library object file. Any options specified in the $SHCCFLAGS, $SSHCCFLAGS and $CPPFLAGS construction variables are included on this command line.

SHCCCOMSTR
The string displayed when a C source file is compiled to a shared object file. If this is not set, then $SSHCCCOM (the command line) is displayed.

env = Environment(SHCCCOMSTR = "Compiling shared object $TARGET")

SHCCFLAGS
Options that are passed to the C and C++ compilers to generate shared-library objects.

SHCCXX
The C++ compiler used for generating shared-library objects.

SHCXXCOM
The command line used to compile a C++ source file to a shared-library object file. Any options specified in the $SHCXXFLAGS and $CPPFLAGS construction variables are included on this command line.
Appendix A. Construction Variables

SHCXXCOMSTR

The string displayed when a C++ source file is compiled to a shared object file. If this is not set, then $SHCXXCOM (the command line) is displayed.

```
env = Environment(SHCXXCOMSTR = "Compiling shared object $TARGET")
```

SHCXXFLAGS

Options that are passed to the C++ compiler to generate shared-library objects.

SHELL

A string naming the shell program that will be passed to the $SPAWN function. See the $SPAWN construction variable for more information.

SHF77

The Fortran 77 compiler used for generating shared-library objects. You should normally set the $SHFORTRAN variable, which specifies the default Fortran compiler for all Fortran versions. You only need to set $SHF77 if you need to use a specific compiler or compiler version for Fortran 77 files.

SHF77COM

The command line used to compile a Fortran 77 source file to a shared-library object file. You only need to set $SHF77COM if you need to use a specific command line for Fortran 77 files. You should normally set the $SHFORTRANCOM variable, which specifies the default command line for all Fortran versions.

SHF77COMSTR

The string displayed when a Fortran 77 source file is compiled to a shared-library object file. If this is not set, then $SHF77COM or $SHFORTRANCOM (the command line) is displayed.

SHF77FLAGS

Options that are passed to the Fortran 77 compiler to generated shared-library objects. You only need to set $SHF77FLAGS if you need to define specific user options for Fortran 77 files. You should normally set the $SHFORTRANFLAGS variable, which specifies the user-specified options passed to the default Fortran compiler for all Fortran versions.

SHF77PPCOM

The command line used to compile a Fortran 77 source file to a shared-library object file after first running the file through the C preprocessor. Any options specified in the $SHF77FLAGS and $CPPFLAGS construction variables are included on this command line. You only need to set $SHF77PPCOM if you need to use a specific C-preprocessor command line for Fortran 77 files. You should normally set the $SHFORTRANPPCOM variable, which specifies the default C-preprocessor command line for all Fortran versions.

SHF77PPCOMSTR

The string displayed when a Fortran 77 source file is compiled to a shared-library object file after first running the file through the C preprocessor. If this is not set, then $SHF77PPCOM or $SHFORTRANPPCOM (the command line) is displayed.
Appendix A. Construction Variables

SHF90
The Fortran 90 compiler used for generating shared-library objects. You should normally set the $SHFORTRAN variable, which specifies the default Fortran compiler for all Fortran versions. You only need to set $SHF90 if you need to use a specific compiler or compiler version for Fortran 90 files.

SHF90COM
The command line used to compile a Fortran 90 source file to a shared-library object file. You only need to set $SHF90COM if you need to use a specific command line for Fortran 90 files. You should normally set the $SHFORTRANCOM variable, which specifies the default command line for all Fortran versions.

SHF90COMSTR
The string displayed when a Fortran 90 source file is compiled to a shared-library object file. If this is not set, then $SHF90COM or $SHFORTRANCOM (the command line) is displayed.

SHF90FLAGS
Options that are passed to the Fortran 90 compiler to generated shared-library objects. You only need to set $SHF90FLAGS if you need to define specific user options for Fortran 90 files. You should normally set the $SHFORTRANFLAGS variable, which specifies the user-specified options passed to the default Fortran compiler for all Fortran versions.

SHF90PPCOM
The command line used to compile a Fortran 90 source file to a shared-library object file after first running the file through the C preprocessor. Any options specified in the $SHF90FLAGS and $CPPFLAGS construction variables are included on this command line. You only need to set $SHF90PPCOM if you need to use a specific C-preprocessor command line for Fortran 90 files. You should normally set the $SHFORTRANPPCOM variable, which specifies the default C-preprocessor command line for all Fortran versions.

SHF90PPCOMSTR
The string displayed when a Fortran 90 source file is compiled to a shared-library object file after first running the file through the C preprocessor. If this is not set, then $SHF90PPCOM or $SHFORTRANPPCOM (the command line) is displayed.

SHF95
The Fortran 95 compiler used for generating shared-library objects. You should normally set the $SHFORTRAN variable, which specifies the default Fortran compiler for all Fortran versions. You only need to set $SHF95 if you need to use a specific compiler or compiler version for Fortran 95 files.

SHF95COM
The command line used to compile a Fortran 95 source file to a shared-library object file. You only need to set $SHF95COM if you need to use a specific command line for Fortran 95 files. You should normally set the $SHFORTRANCOM variable, which specifies the default command line for all Fortran versions.
Appendix A. Construction Variables

SHF95COMSTR
The string displayed when a Fortran 95 source file is compiled to a shared-library object file. If this is not set, then $SHF95COM or $SHFORTRANCOM (the command line) is displayed.

SHF95FLAGS
Options that are passed to the Fortran 95 compiler to generated shared-library objects. You only need to set $SHF95FLAGS if you need to define specific user options for Fortran 95 files. You should normally set the $SHFORTRANFLAGS variable, which specifies the user-specified options passed to the default Fortran compiler for all Fortran versions.

SHF95PPCOM
The command line used to compile a Fortran 95 source file to a shared-library object file after first running the file through the C preprocessor. Any options specified in the $SHF95FLAGS and $CPPFLAGS construction variables are included on this command line. You only need to set $SHF95PPCOM if you need to use a specific C-preprocessor command line for Fortran 95 files. You should normally set the $SHFORTRANPPCOM variable, which specifies the default C-preprocessor command line for all Fortran versions.

SHF95PPCOMSTR
The string displayed when a Fortran 95 source file is compiled to a shared-library object file after first running the file through the C preprocessor. If this is not set, then $SHF95PPCOM or $SHFORTRANPPCOM (the command line) is displayed.

SHFORTRAN
The default Fortran compiler used for generating shared-library objects.

SHFORTRANCOM
The command line used to compile a Fortran source file to a shared-library object file.

SHFORTRANCOMSTR
The string displayed when a Fortran source file is compiled to a shared-library object file. If this is not set, then $SHFORTRANCOM (the command line) is displayed.

SHFORTRANFLAGS
Options that are passed to the Fortran compiler to generate shared-library objects.

SHFORTRANPPCOM
The command line used to compile a Fortran source file to a shared-library object file after first running the file through the C preprocessor. Any options specified in the $SHFORTRANFLAGS and $CPPFLAGS construction variables are included on this command line.

SHFORTRANPPCOMSTR
The string displayed when a Fortran source file is compiled to a shared-library object file after first running the file through the C preprocessor. If this is not set, then $SHFORTRANPPCOM (the command line) is displayed.
Appendix A. Construction Variables

SHLIBPREFIX
The prefix used for shared library file names.

SHLIBSUFFIX
The suffix used for shared library file names.

SHLINK
The linker for programs that use shared libraries.

SHLINKCOM
The command line used to link programs using shared libraries.

SHLINKCOMSTR
The string displayed when programs using shared libraries are linked. If this is not set, then $SHLINKCOM (the command line) is displayed.

env = Environment(SHLINKCOMSTR = "Linking shared $TARGET")

SHLINKFLAGS
General user options passed to the linker for programs using shared libraries. Note that this variable should not contain -l (or similar) options for linking with the libraries listed in $LIBS, nor -L (or similar) include search path options that scons generates automatically from $LIBPATH. See $_LIBFLAGS above, for the variable that expands to library-link options, and $_LIBDIRFLAGS above, for the variable that expands to library search path options.

SHOBJPREFIX
The prefix used for shared object file names.

SHOBJSUFFIX
The suffix used for shared object file names.

SOURCE
A reserved variable name that may not be set or used in a construction environment. (See "Variable Substitution," below.)

SOURCE_URL
The URL (web address) of the location from which the project was retrieved. This is used to fill in the Source: field in the controlling information for Ipkg and RPM packages.

SOURCES
A reserved variable name that may not be set or used in a construction environment. (See "Variable Substitution," below.)

SPAWN
A command interpreter function that will be called to execute command line strings. The function must expect the following arguments:
def spawn(shell, escape, cmd, args, env):

    sh is a string naming the shell program to use. escape is a function that can be called to escape shell special characters in the command line. cmd is the path to the command to be executed. args is the arguments to the command. env is a dictionary of the environment variables in which the command should be executed.

SUMMARY

A short summary of what the project is about. This is used to fill in the Summary: field in the controlling information for Ipkg and RPM packages, and as the Description: field in MSI packages.

SWIG

The scripting language wrapper and interface generator.

SWIGCFILESUFFIX

The suffix that will be used for intermediate C source files generated by the scripting language wrapper and interface generator. The default value is _wrap$CFILESUFFIX. By default, this value is used whenever the -c++ option is not specified as part of the $SWIGFLAGS construction variable.

SWIGCOM

The command line used to call the scripting language wrapper and interface generator.

SWIGCOMSTR

The string displayed when calling the scripting language wrapper and interface generator. If this is not set, then $SWIGCOM (the command line) is displayed.

SWIGCXXFILESUFFIX

The suffix that will be used for intermediate C++ source files generated by the scripting language wrapper and interface generator. The default value is _wrap$CFILESUFFIX. By default, this value is used whenever the -c++ option is specified as part of the $SWIGFLAGS construction variable.

SWIGFLAGS

General options passed to the scripting language wrapper and interface generator. This is where you should set -python, -perl5, -tcl, or whatever other options you want to specify to SWIG. If you set the -c++ option in this variable, scons will, by default, generate a C++ intermediate source file with the extension that is specified as the $CXXFILESUFFIX variable.

_SWIGINCFLAGS

An automatically-generated construction variable containing the SWIG command-line options for specifying directories to be searched for included files. The value of $SWIGINCFLAGS is created by appending $SWIGINCPREFIX and $SWIGINCSUFFIX to the beginning and end of each directory in $SWIGPATH.
Appendix A. Construction Variables

SWIGINCPREFIX

The prefix used to specify an include directory on the SWIG command line. This will be appended to the beginning of each directory in the $SWIGPATH construction variable when the $SWIGINCFLAGS variable is automatically generated.

SWIGINCSUFFIX

The suffix used to specify an include directory on the SWIG command line. This will be appended to the end of each directory in the $SWIGPATH construction variable when the $SWIGINCFLAGS variable is automatically generated.

SWIGOUTDIR

Specifies the output directory in which the scripting language wrapper and interface generator should place generated language-specific files. This will be used by SCons to identify the files that will be generated by the swig call, and translated into the `swig -outdir` option on the command line.

SWIGPATH

The list of directories that the scripting language wrapper and interface generate will search for included files. The SWIG implicit dependency scanner will search these directories for include files. The default is to use the same path specified as $CPPPATH.

Don’t explicitly put include directory arguments in SWIGFLAGS; the result will be non-portable and the directories will not be searched by the dependency scanner. Note: directory names in SWIGPATH will be looked-up relative to the SConscript directory when they are used in a command. To force scons to look-up a directory relative to the root of the source tree use #: 

```
env = Environment(SWIGPATH='#/include')
```

The directory look-up can also be forced using the Dir() function:

```
include = Dir('include')
env = Environment(SWIGPATH=include)
```

The directory list will be added to command lines through the automatically-generated $SWIGINCFLAGS construction variable, which is constructed by appending the values of the $SWIGINCPREFIX and $SWIGINCSUFFIX construction variables to the beginning and end of each directory in $SWIGPATH. Any command lines you define that need the SWIGPATH directory list should include $SWIGINCFLAGS:

```
env = Environment(SWIGCOM="my_swig -o $TARGET $SWIGINCFLAGS $SOURCES")
```

TAR

The tar archiver.

TARCOM

The command line used to call the tar archiver.
Appendix A. Construction Variables

TARCOMSTR

The string displayed when archiving files using the tar archiver. If this is not set, then \$TARCOM (the command line) is displayed.

\texttt{env = Environment(TARCOMSTR = "Archiving \$TARGET")}

TARFLAGS

General options passed to the tar archiver.

TARGET

A reserved variable name that may not be set or used in a construction environment. (See "Variable Substitution," below.)

TARGETS

A reserved variable name that may not be set or used in a construction environment. (See "Variable Substitution," below.)

TARSUFFIX

The suffix used for tar file names.

TEMPFILEPREFIX

The prefix for a temporary file used to execute lines longer than \$MAXLINELENGTH. The default is '@'. This may be set for toolchains that use other values, such as '-@' for the diab compiler or '-via' for ARM toolchain.

TEX

The TeX formatter and typesetter.

TEXCOM

The command line used to call the TeX formatter and typesetter.

TEXCOMSTR

The string displayed when calling the TeX formatter and typesetter. If this is not set, then \$TEXCOM (the command line) is displayed.

\texttt{env = Environment(TEXCOMSTR = "Building \$TARGET from TeX input \$SOURCES")}

TEXFLAGS

General options passed to the TeX formatter and typesetter.

TEXINPUTS

List of directories that the LaTeX programm will search for include directories. The LaTeX implicit dependency scanner will search these directories for \include and \import files.

TOOLS

A list of the names of the Tool specifications that are part of this construction environment.
Appendix A. Construction Variables

VENDOR

The person or organization who supply the packaged software. This is used to fill in the Vendor: field in the controlling information for RPM packages, and the Manufacturer: field in the controlling information for MSI packages.

VERSION

The version of the project, specified as a string.

WIN32_INSERT_DEF

A deprecated synonym for $WINDOWS_INSERT_DEF.

WIN32DEFPREFIX

A deprecated synonym for $WINDOWSDEFPREFIX.

WIN32DEFSUFFIX

A deprecated synonym for $WINDOWSDEFSUFFIX.

WIN32EXPPREFIX

A deprecated synonym for $WINDOWSEXPSUFFIX.

WIN32EXPSUFFIX

A deprecated synonym for $WINDOWSEXPSUFFIX.

WINDOWS_INSERT_DEF

When this is set to true, a library build of a Windows shared library (.dll file) will also build a corresponding .def file at the same time, if a .def file is not already listed as a build target. The default is 0 (do not build a .def file).

WINDOWS_INSERT_MANIFEST

When this is set to true, scons will be aware of the .manifest files generated by Microsoft Visual C/C++ 8.

WINDOWSDEFPREFIX

The prefix used for Windows .def file names.

WINDOWSDEFSUFFIX

The suffix used for Windows .def file names.

WINDOWSEXPPREFIX

The prefix used for Windows .exp file names.

WINDOWSEXPSUFFIX

The suffix used for Windows .exp file names.
Appendix A. Construction Variables

WINDOWSPROGMANIFESTPREFIX
The prefix used for executable program .manifest files generated by Microsoft Visual C/C++.

WINDOWSPROGMANIFESTSUFFIX
The suffix used for executable program .manifest files generated by Microsoft Visual C/C++.

WINDOWSSHLIBMANIFESTPREFIX
The prefix used for shared library .manifest files generated by Microsoft Visual C/C++.

WINDOWSSHLIBMANIFESTSUFFIX
The suffix used for shared library .manifest files generated by Microsoft Visual C/C++.

X_IPK_DEPENDS
This is used to fill in the Depends: field in the controlling information for Ipkg packages.

X_IPK_DESCRIPTION
This is used to fill in the Description: field in the controlling information for Ipkg packages. The default value is $SUMMARY\n$DESCRIPTION

X_IPK_MAINTAINER
This is used to fill in the Maintainer: field in the controlling information for Ipkg packages.

X_IPK_PRIORITY
This is used to fill in the Priority: field in the controlling information for Ipkg packages.

X_IPK_SECTION
This is used to fill in the Section: field in the controlling information for Ipkg packages.

X_MSI_LANGUAGE
This is used to fill in the Language: attribute in the controlling information for MSI packages.

X_MSI_LICENSE_TEXT
The text of the software license in RTF format. Carriage return characters will be replaced with the RTF equivalent \par.

X_MSI_UPGRADE_CODE
TODO

X_RPM_AUTOREQPROV
This is used to fill in the AutoReqProv: field in the RPM .spec file.

X_RPM_BUILD
internal, but overridable
Appendix A. Construction Variables

X_RPM_BUILDREQUIRES
This is used to fill in the BuildRequires: field in the RPM .spec file.

X_RPM_BUILDROOT
internal, but overridable

X_RPM_CLEAN
internal, but overridable

X_RPM_CONFLICTS
This is used to fill in the Conflicts: field in the RPM .spec file.

X_RPM_DEFATTR
This value is used as the default attributes for the files in the RPM package. The default value is (-,root,root).

X_RPM_DISTRIBUTION
This is used to fill in the Distribution: field in the RPM .spec file.

X_RPM_EPOCH
This is used to fill in the Epoch: field in the controlling information for RPM packages.

X_RPM_EXCLUDEARCH
This is used to fill in the ExcludeArch: field in the RPM .spec file.

X_RPM_EXCLUSIVEARCH
This is used to fill in the ExclusiveArch: field in the RPM .spec file.

X_RPM_GROUP
This is used to fill in the Group: field in the RPM .spec file.

X_RPM_GROUP_lang
This is used to fill in the Group(lang): field in the RPM .spec file. Note that lang is not literal and should be replaced by the appropriate language code.

X_RPM_ICON
This is used to fill in the Icon: field in the RPM .spec file.

X_RPM_INSTALL
internal, but overridable

X_RPM_PACKAGER
This is used to fill in the Packager: field in the RPM .spec file.
Appendix A. Construction Variables

X_RPM_POSTINSTALL
This is used to fill in the %post: section in the RPM .spec file.

X_RPM_POSTUNINSTALL
This is used to fill in the %postun: section in the RPM .spec file.

X_RPM_PREFIX
This is used to fill in the Prefix: field in the RPM .spec file.

X_RPM_PREINSTALL
This is used to fill in the %pre: section in the RPM .spec file.

X_RPM_PREP
internal, but overridable

X_RPM_PREUNINSTALL
This is used to fill in the %preun: section in the RPM .spec file.

X_RPM_PROVIDES
This is used to fill in the Provides: field in the RPM .spec file.

X_RPM_REQUIRES
This is used to fill in the Requires: field in the RPM .spec file.

X_RPM_SERIAL
This is used to fill in the Serial: field in the RPM .spec file.

X_RPM_URL
This is used to fill in the Url: field in the RPM .spec file.

YACC
The parser generator.

YACCCOM
The command line used to call the parser generator to generate a source file.

YACCCOMSTR
The string displayed when generating a source file using the parser generator. If this is not set, then $YACCCOM (the command line) is displayed.

env = Environment(YACCCOMSTR = "Yacc’ing $TARGET from $SOURCES")

YACCCFLAGS
General options passed to the parser generator. If $YACCCFLAGS contains a -d option, SCons assumes that the call will also create a .h file (if the yacc source file ends in a .y suffix) or a .hpp file (if the yacc source file ends in a .yy suffix)
Appendix A. Construction Variables

YACCHFILESUFFIX
The suffix of the C header file generated by the parser generator when the \(-d\) option is used. Note that setting this variable does not cause the parser generator to generate a header file with the specified suffix, it exists to allow you to specify what suffix the parser generator will use of its own accord. The default value is \(\cdot h\).

YACCHXXFILESUFFIX
The suffix of the C++ header file generated by the parser generator when the \(-d\) option is used. Note that setting this variable does not cause the parser generator to generate a header file with the specified suffix, it exists to allow you to specify what suffix the parser generator will use of its own accord. The default value is \(\cdot hpp\), except on Mac OS X, where the default is \(\$\{TARGET.suffix\}.h\) because the default bison parser generator just appends \(\cdot h\) to the name of the generated C++ file.

YACCVCGFILESUFFIX
The suffix of the file containing the VCG grammar automaton definition when the \(--graph=\) option is used. Note that setting this variable does not cause the parser generator to generate a VCG file with the specified suffix, it exists to allow you to specify what suffix the parser generator will use of its own accord. The default value is \(\cdot vcg\).

ZIP
The zip compression and file packaging utility.

ZIPCOM
The command line used to call the zip utility, or the internal Python function used to create a zip archive.

ZIPCOMPRESSION
The \texttt{compression} flag from the Python \texttt{zipfile} module used by the internal Python function to control whether the zip archive is compressed or not. The default value is \texttt{zipfile.ZIP_DEFLATED}, which creates a compressed zip archive. This value has no effect when using Python 1.5.2 or if the \texttt{zipfile} module is otherwise unavailable.

ZIPCOMSTR
The string displayed when archiving files using the zip utility. If this is not set, then \$\{ZIPCOM\} (the command line or internal Python function) is displayed.

\begin{verbatim}
env = Environment(ZIPCOMSTR = "Zipping $TARGET")
\end{verbatim}

ZIPFLAGS
General options passed to the zip utility.

ZIPSUFFIX
The suffix used for zip file names.
Appendix B. Builders

This appendix contains descriptions of all of the Builders that are potentially available "out of the box" in this version of SCons.

CFile()

env.CFile()

Builds a C source file given a lex (.l) or yacc (.y) input file. The suffix specified by the $CFILESUFFIX construction variable (.c by default) is automatically added to the target if it is not already present. Example:

# builds foo.c
env.CFile(target = 'foo.c', source = 'foo.l')
# builds bar.c
env.CFile(target = 'bar', source = 'bar.y')

CXXFile()

env.CXXFile()

Builds a C++ source file given a lex (.ll) or yacc (.yy) input file. The suffix specified by the $CXXFILESUFFIX construction variable (.cc by default) is automatically added to the target if it is not already present. Example:

# builds foo.cc
env.CXXFile(target = 'foo.cc', source = 'foo.ll')
# builds bar.cc
env.CXXFile(target = 'bar', source = 'bar.yy')

DVI()

env.DVI()

Builds a .dvi file from a .tex, .ltex or .latex input file. If the source file suffix is .tex, scons will examine the contents of the file; if the string \documentclass or \documentstyle is found, the file is assumed to be a LaTeX file and the target is built by invoking the $LATEXCOM command line; otherwise, the $TEXCOM command line is used. If the file is a LaTeX file, the DVI builder method will also examine the contents of the .aux file and invoke the $BIBTEX command line if the string bibdata is found, start $MAKEINDEX to generate an index if a .ind file is found and will examine the contents .log file and re-run the $LATEXCOM command if the log file says it is necessary.

The suffix .dvi (hard-coded within TeX itself) is automatically added to the target if it is not already present. Examples:

# builds from aaa.tex
env.DVI(target = 'aaa.dvi', source = 'aaa.tex')
# builds bbb.dvi
env.DVI(target = 'bbb', source = 'bbb.ltx')
# builds from ccc.latex
env.DVI(target = 'ccc.dvi', source = 'ccc.latex')
Install()
env.Install()

Installs one or more source files or directories in the specified target, which must be a directory. The names of the specified source files or directories remain the same within the destination directory.

env.Install('/usr/local/bin', source = ['foo', 'bar'])

InstallAs()
env.InstallAs()

Installs one or more source files or directories to specific names, allowing changing a file or directory name as part of the installation. It is an error if the target and source arguments list different numbers of files or directories.

env.InstallAs(target = '/usr/local/bin/foo',
              source = 'foo_debug')
env.InstallAs(target = ['../lib/libfoo.a', '../lib/libbar.a'],
              source = ['libFOO.a', 'libBAR.a'])

Jar()
env.Jar()

Builds a Java archive (.jar) file from the specified list of sources. Any directories in the source list will be searched for .class files. Any .java files in the source list will be compiled to .class files by calling the Java Builder.

If the $JARCHDIR value is set, the jar command will change to the specified directory using the -C option. If $JARCHDIR is not set explicitly, SCons will use the top of any subdirectory tree in which Java .class were built by the Java Builder.

If the contents any of the source files begin with the string Manifest-Version, the file is assumed to be a manifest and is passed to the jar command with the m option set.

env.Jar(target = 'foo.jar', source = 'classes')
env.Jar(target = 'bar.jar',
        source = ['bar1.java', 'bar2.java'])

Java()
env.Java()

Builds one or more Java class files. The sources may be any combination of explicit .java files, or directory trees which will be scanned for .java files.

SCons will parse each source .java file to find the classes (including inner classes) defined within that file, and from that figure out the target .class files that will be created. The class files will be placed underneath the specified target directory.

SCons will also search each Java file for the Java package name, which it assumes can be found on a line beginning with the string package in the first column; the resulting .class files will be placed
Appendix B. Builders

in a directory reflecting the specified package name. For example, the file Foo.java defining a single public Foo class and containing a package name of sub.dir will generate a corresponding sub/dir/Foo.class class file.

Examples:

env.Java(target = 'classes', source = 'src')
env.Java(target = 'classes', source = ['src1', 'src2'])
env.Java(target = 'classes', source = ['File1.java', 'File2.java'])

Java source files can use the native encoding for the underlying OS. Since SCons compiles in simple ASCII mode by default, the compiler will generate warnings about unmappable characters, which may lead to errors as the file is processed further. In this case, the user must specify the LANG environment variable to tell the compiler what encoding is used. For portibility, it’s best if the encoding is hard-coded so that the compile will work if it is done on a system with a different encoding.

env = Environment()
env['ENV'][LANG] = 'en_GB.UTF-8'

JavaH()
env.JavaH()

Builds C header and source files for implementing Java native methods. The target can be either a directory in which the header files will be written, or a header file name which will contain all of the definitions. The source can be the names of .class files, the names of .java files to be compiled into .class files by calling the Java builder method, or the objects returned from the Java builder method.

If the construction variable $JAVACLASSDIR is set, either in the environment or in the call to the JavaH builder method itself, then the value of the variable will be stripped from the beginning of any .class file names.

Examples:

# builds java_native.h
classes = env.Java(target = 'classdir', source = 'src')
env.JavaH(target = 'java_native.h', source = classes)

# builds include/package_foo.h and include/package_bar.h
env.JavaH(target = 'include',
    source = ['package/foo.class', 'package/bar.class'])

# builds export/foo.h and export/bar.h
env.JavaH(target = 'export',
    source = ['classes/foo.class', 'classes/bar.class'],
    JAVACLASSDIR = 'classes')
Appendix B. Builders

Library()
env.Library()

A synonym for the StaticLibrary builder method.

LoadableModule()
env.LoadableModule()

On most systems, this is the same as SharedLibrary. On Mac OS X (Darwin) platforms, this creates a loadable module bundle.

M4()
env.M4()

Builds an output file from an M4 input file. This uses a default $M4FLAGS value of -E, which considers all warnings to be fatal and stops on the first warning when using the GNU version of m4. Example:

```
env.M4(target = 'foo.c', source = 'foo.c.m4')
```

Moc()
env.Moc()

Builds an output file from a moc input file. Moc input files are either header files or cxx files. This builder is only available after using the tool 'qt'. See the $QTDIR variable for more information. Example:

```
env.Moc('foo.h')  # generates moc_foo.cc
env.Moc('foo.cpp')  # generates foo.moc
```

MSVSProject()
env.MSVSProject()

Builds a Microsoft Visual Studio project file, and by default builds a solution file as well.

This builds a Visual Studio project file, based on the version of Visual Studio that is configured (either the latest installed version, or the version specified by $MSVS_VERSION in the Environment constructor). For Visual Studio 6, it will generate a .dsp file. For Visual Studio 7 (.NET) and later versions, it will generate a .vcproj file.

By default, this also generates a solution file for the specified project, a .dsw file for Visual Studio 6 or a .sln file for Visual Studio 7 (.NET). This behavior may be disabled by specifying auto_build_solution=0 when you call MSVSProject, in which case you presumably want to build the solution file(s) by calling the MSVSSolution Builder (see below).

The MSVSProject builder takes several lists of filenames to be placed into the project file. These are currently limited to srcs, incs, localincs, resources, and misc. These are pretty self-explanatory, but it should be noted that these lists are added to the $SOURCES construction variable as strings, NOT as SCons File Nodes. This is because they represent file names to be added to the project file, not the source files used to build the project file.
The above filename lists are all optional, although at least one must be specified for the resulting project file to be non-empty.

In addition to the above lists of values, the following values may be specified:

- **target**: The name of the target .dsp or .vcproj file. The correct suffix for the version of Visual Studio must be used, but the $MSVSPROJECTSUFFIX construction variable will be defined to the correct value (see example below).

- **variant**: The name of this particular variant. For Visual Studio 7 projects, this can also be a list of variant names. These are typically things like "Debug" or "Release", but really can be anything you want. For Visual Studio 7 projects, they may also specify a target platform separated from the variant name by a | (vertical pipe) character: Debug|Xbox. The default target platform is Win32. Multiple calls to MSVSProject with different variants are allowed; all variants will be added to the project file with their appropriate build targets and sources.

- **buildtarget**: An optional string, node, or list of strings or nodes (one per build variant), to tell the Visual Studio debugger what output target to use in what build variant. The number of buildtarget entries must match the number of variant entries.

- **runfile**: The name of the file that Visual Studio 7 and later will run and debug. This appears as the value of the Output field in the resulting Visual Studio project file. If this is not specified, the default is the same as the specified buildtarget value.

Note that because SCons always executes its build commands from the directory in which the SConstruct file is located, if you generate a project file in a different directory than the SConstruct directory, users will not be able to double-click on the file name in compilation error messages displayed in the Visual Studio console output window. This can be remedied by adding the Visual C/C++ .B /FC compiler option to the $CCFLAGS variable so that the compiler will print the full path name of any files that cause compilation errors.

**Example usage:**

```python
barsrcs = ['bar.cpp'],
barincs = ['bar.h'],
barlocalincs = ['StdAfx.h']
barresources = ['bar.rc','resource.h']
barmisc = ['bar_readme.txt']

dll = env.SharedLibrary(target = 'bar.dll',
                        source = barsrcs)

e.env.MSVSProject(target = 'Bar' + env['MSVSPROJECTSUFFIX'],
                  srcs = barsrcs,
                  incs = barincs,
                  localincs = barlocalincs,
```
resources = barresources,
misc = barmisc,
buildtarget = dll,
variant = 'Release')

MSVSSolution()
env.MSVSSolution()

Builds a Microsoft Visual Studio solution file.

This builds a Visual Studio solution file, based on the version of Visual Studio that is configured (either the latest installed version, or the version specified by $MSVS_VERSION in the construction environment). For Visual Studio 6, it will generate a .dsw file. For Visual Studio 7 (.NET), it will generate a .sln file.

The following values must be specified:

target: The name of the target .dsw or .sln file. The correct suffix for the version of Visual Studio must be used, but the value $MSVSSOLUTIONSUFFIX will be defined to the correct value (see example below).

variant: The name of this particular variant, or a list of variant names (the latter is only supported for MSVS 7 solutions). These are typically things like "Debug" or "Release", but really can be anything you want. For MSVS 7 they may also specify target platform, like this "Debug|Xbox". Default platform is Win32.

projects: A list of project file names, or Project nodes returned by calls to the MSVSProject Builder, to be placed into the solution file. It should be noted that these file names are NOT added to the $SOURCES environment variable in form of files, but rather as strings. This is because they represent file names to be added to the solution file, not the source files used to build the solution file.

(NOTE: Currently only one project is supported per solution.)

Example Usage:

env.MSVSSolution(target = ‘Bar’ + env[‘MSVSSOLUTIONSUFFIX’],
                projects = [‘bar’ + env[‘MSVSPROJECTSUFFIX’]],
                variant = ‘Release’)

Object()
env.Object()

A synonym for the StaticObject builder method.
Appendix B. Builders

Package()
env.Package()

Builds software distribution packages. Packages consist of files to install and packaging information. The former may be specified with the source parameter and may be left out, in which case the FindInstalledFiles function will collect all files that have an Install or InstallAs Builder attached. If the target is not specified it will be deduced from additional information given to this Builder.

The packaging information is specified with the help of construction variables documented below. This information is called a tag to stress that some of them can also be attached to files with the Tag function. The mandatory ones will complain if they were not specified. They vary depending on chosen target packager.

The target packager may be selected with the "PACKAGETYPE" command line option or with the $PACKAGETYPE construction variable. Currently the following packagers available:

* msi - Microsoft Installer
* rpm - Redhat Package Manager
* ipkg - Itsy Package Management System
* tarbz2 - compressed tar
* targz - compressed tar
* zip - zip file
* src_tarbz2 - compressed tar source
* src_targz - compressed tar source
* src_zip - zip file source

An updated list is always available under the "package_type" option when running "scons --help" on a project that has packaging activated.

env = Environment(tools=['default', 'packaging'])
env.Install('/bin/', 'my_program')
env.Package( NAME = 'foo',
             VERSION = '1.2.3',
             PACKAGEVERSION = 0,
             PACKAGETYPE = 'rpm',
             LICENSE = 'gpl',
             SUMMARY = 'balalalalalal',
             DESCRIPTION = 'this should be really really long',
             X_RPM_GROUP = 'Application/fu',
             SOURCE_URL = 'http://foo.org/foo-1.2.3.tar.gz')

PCH()
env.PCH()

Builds a Microsoft Visual C++ precompiled header. Calling this builder method returns a list of two targets: the PCH as the first element, and the object file as the second element. Normally the object file is ignored. This builder method is only provided when Microsoft Visual C++ is being used as the compiler. The PCH builder method is generally used in conjunction with the PCH construction variable to force object files to use the precompiled header:

env['PCH'] = env.PCH('StdAfx.cpp')[0]
Appendix B. Builders

PDF()
env.PDF()

Builds a .pdf file from a .dvi input file (or, by extension, a .tex, .ltx, or .latex input file). The suffix specified by the $PDFSUFFIX construction variable (.pdf by default) is added automatically to the target if it is not already present. Example:

# builds from aaa.tex
env.PDF(target = ‘aaa.pdf’, source = ‘aaa.tex’)  
# builds bbb.pdf from bbb.dvi
env.PDF(target = ‘bbb’, source = ‘bbb.dvi’)

PostScript()
env.PostScript()

Builds a .ps file from a .dvi input file (or, by extension, a .tex, .ltx, or .latex input file). The suffix specified by the $PSSUFFIX construction variable (.ps by default) is added automatically to the target if it is not already present. Example:

# builds from aaa.tex
env.PostScript(target = ‘aaa.ps’, source = ‘aaa.tex’)  
# builds bbb.ps from bbb.dvi
env.PostScript(target = ‘bbb’, source = ‘bbb.dvi’)

Program()
env.Program()

Builds an executable given one or more object files or C, C++, D, or Fortran source files. If any C, C++, D or Fortran source files are specified, then they will be automatically compiled to object files using the Object builder method; see that builder method’s description for a list of legal source file suffixes and how they are interpreted. The target executable file prefix (specified by the $PROGPREFIX construction variable; nothing by default) and suffix (specified by the $PROGSUFFIX construction variable; by default, .exe on Windows systems, nothing on POSIX systems) are automatically added to the target if not already present. Example:

env.Program(target = ‘foo’, source = [‘foo.o’, ‘bar.c’, ‘baz.f’])

RES()  
env.RES()

Builds a Microsoft Visual C++ resource file. This builder method is only provided when Microsoft Visual C++ or MinGW is being used as the compiler. The .res (or .o for MinGW) suffix is added to the target name if no other suffix is given. The source file is scanned for implicit dependencies as though it were a C file. Example:

env.RES(‘resource.rc’)  

RMI()  
env.RMI()

Builds stub and skeleton class files for remote objects from Java .class files. The target is a directory relative to which the stub and skeleton class files will be written. The source can be the names of .class files, or the objects return from the Java builder method.
Appendix B. Builders

If the construction variable $JAVACLASSDIR is set, either in the environment or in the call to the RMIC builder method itself, then the value of the variable will be stripped from the beginning of any .class file names.

classes = env.Java(target = 'classdir', source = 'src')
env.RMIC(target = 'outdir1', source = classes)

env.RMIC(target = 'outdir2',
         source = ['package/foo.class', 'package/bar.class'])

env.RMIC(target = 'outdir3',
         source = ['classes/foo.class', 'classes/bar.class'],
         JAVACLASSDIR = 'classes')

RPCGenClient()
env.RPCGenClient()

Generates an RPC client stub (_clnt.c) file from a specified RPC (.x) source file. Because rpcgen only builds output files in the local directory, the command will be executed in the source file’s directory by default.

# Builds src/rpcif_clnt.c
env.RPCGenClient('src/rpcif.x')

RPCGenHeader()
env.RPCGenHeader()

Generates an RPC header (.h) file from a specified RPC (.x) source file. Because rpcgen only builds output files in the local directory, the command will be executed in the source file’s directory by default.

# Builds src/rpcif.h
env.RPCGenHeader('src/rpcif.x')

RPCGenService()
env.RPCGenService()

Generates an RPC server-skeleton (_svc.c) file from a specified RPC (.x) source file. Because rpcgen only builds output files in the local directory, the command will be executed in the source file’s directory by default.

# Builds src/rpcif_svc.c
env.RPCGenClient('src/rpcif.x')

RPCGenXDR()
env.RPCGenXDR()

Generates an RPC XDR routine (_xdr.c) file from a specified RPC (.x) source file. Because rpcgen only builds output files in the local directory, the command will be executed in the source file’s directory by default.

# Builds src/rpcif_xdr.c
env.RPCGenClient('src/rpcif.x')
Appendix B. Builders

SharedLibrary()

env.SharedLibrary()

Builds a shared library (`.so` on a POSIX system, `.dll` on Windows) given one or more object files or C, C++, D or Fortran source files. If any source files are given, then they will be automatically compiled to object files. The static library prefix and suffix (if any) are automatically added to the target. The target library file prefix (specified by the `$SHLIBPREFIX` construction variable; by default, `lib` on POSIX systems, nothing on Windows systems) and suffix (specified by the `$SHLIBSUFFIX` construction variable; by default, `.dll` on Windows systems, `.so` on POSIX systems) are automatically added to the target if not already present. Example:

```python
env.SharedLibrary(target = 'bar', source = ['bar.c', 'foo.o'])
```

On Windows systems, the `SharedLibrary` builder method will always build an import (`.lib`) library in addition to the shared (`.dll`) library, adding a `.lib` library with the same basename if there is not already a `.lib` file explicitly listed in the targets.

Any object files listed in the `source` must have been built for a shared library (that is, using the `SharedObject` builder method). `scons` will raise an error if there is any mismatch.

On Windows systems, specifying `register=1` will cause the `.dll` to be registered after it is built using `REGSVR32`. The command that is run ("regsvr32" by default) is determined by `$REGSVR` construction variable, and the flags passed are determined by `$REGSVRFLAGS`. By default, `$REGSVRFLAGS` includes the `/s` option, to prevent dialogs from popping up and requiring user attention when it is run. If you change `$REGSVRFLAGS`, be sure to include the `/s` option. For example,

```python
env.SharedLibrary(target = 'bar',
                 source = ['bar.cxx', 'foo.obj'],
                 register=1)
```

will register `bar.dll` as a COM object when it is done linking it.

SharedObject()

env.SharedObject()

Builds an object file for inclusion in a shared library. Source files must have one of the same set of extensions specified above for the `StaticObject` builder method. On some platforms building a shared object requires additional compiler option (e.g. `-fPIC` for gcc) in addition to those needed to build a normal (static) object, but on some platforms there is no difference between a shared object and a normal (static) one. When there is a difference, SCons will only allow shared objects to be linked into a shared library, and will use a different suffix for shared objects. On platforms where there is no difference, SCons will allow both normal (static) and shared objects to be linked into a shared library, and will use the same suffix for shared and normal (static) objects. The target object file prefix (specified by the `$SHOBJPREFIX` construction variable; by default, the same as `$OBJPREFIX`) and suffix (specified by the `$SHOBJSUFFIX` construction variable) are automatically added to the target if not already present. Examples:
env.SharedObject(target = 'ddd', source = 'ddd.c')
env.SharedObject(target = 'eee.o', source = 'eee.cpp')
env.SharedObject(target = 'fff.obj', source = 'fff.for')

Note that the source files will be scanned according to the suffix mappings in the
SourceFileScanner object. See the section "Scanner Objects," below, for a more information.

StaticLibrary()
env.StaticLibrary()

Builds a static library given one or more object files or C, C++, D or Fortran source files. If any
source files are given, then they will be automatically compiled to object files. The static library
prefix and suffix (if any) are automatically added to the target. The target library file prefix
(specified by the $LIBPREFIX construction variable; by default, lib on POSIX systems, nothing
on Windows systems) and suffix (specified by the $LIBSUFFIX construction variable; by default,
.lib on Windows systems, .a on POSIX systems) are automatically added to the target if not
already present. Example:

env.StaticLibrary(target = 'bar', source = ['bar.c', 'foo.o'])

Any object files listed in the source must have been built for a static library (that is, using the
StaticObject builder method). scons will raise an error if there is any mismatch.

StaticObject()
env.StaticObject()

Builds a static object file from one or more C, C++, D, or Fortran source files. Source files must
have one of the following extensions:

- .asm assembly language file
- .ASM assembly language file
- .c C file
- .C Windows: C file
  POSIX: C++ file
- .cc C++ file
- .cpp C++ file
- .cxx C++ file
- .c++ C++ file
- .cpp C++ file
- .d D file
- .f Fortran file
- .F Windows: Fortran file
  POSIX: Fortran file + C pre-processor
- .for Fortran file
- .FOR Fortran file
- .fpp Fortran file + C pre-processor
- .FP Fortran file + C pre-processor
- .m Object C file
- .mm Object C++ file
Appendix B. Builders

.s  assembly language file
.S  Windows: assembly language file
ARM: CodeSourcery Sourcery Lite
.sx  assembly language file + C pre-processor
POSIX: assembly language file + C pre-processor
.spp  assembly language file + C pre-processor
.SPP assembly language file + C pre-processor

The target object file prefix (specified by the $OBJPREFIX construction variable; nothing by default) and suffix (specified by the $OBJSUFFIX construction variable; .obj on Windows systems, .o on POSIX systems) are automatically added to the target if not already present. Examples:

env.StaticObject(target = 'aaa', source = 'aaa.c')
env.StaticObject(target = 'bbb.o', source = 'bbb.c++')
env.StaticObject(target = 'ccc.obj', source = 'ccc.f')

Note that the source files will be scanned according to the suffix mappings in SourceFileScanner object. See the section "Scanner Objects," below, for a more information.

Tar()
env.Tar()

Builds a tar archive of the specified files and/or directories. Unlike most builder methods, the Tar builder method may be called multiple times for a given target; each additional call adds to the list of entries that will be built into the archive. Any source directories will be scanned for changes to any on-disk files, regardless of whether or not scons knows about them from other Builder or function calls.

env.Tar('src.tar', 'src')

# Create the stuff.tar file.
env.Tar('stuff', ['subdir1', 'subdir2'])
# Also add "another" to the stuff.tar file.
env.Tar('stuff', 'another')

# Set TARFLAGS to create a gzip-filtered archive.
env = Environment(TARFLAGS = '-c -z')
env.Tar('foo.tar.gz', 'foo')

# Also set the suffix to .tgz.
env = Environment(TARFLAGS = '-c -z',
TARSUFFIX = '.tgz')
env.Tar('foo')

TypeLibrary()
env.TypeLibrary()

Builds a Windows type library (.tlb) file from an input IDL file (.idl). In addition, it will build the associated interface stub and proxy source files, naming them according to the base name of the .idl file. For example,
### Appendix B. Builders

```python
env.Typelibrary(source="foo.idl")

Will create `foo.tlb`, `foo.h`, `foo_i.c`, `foo_p.c` and `foo_data.c` files.
```

```python
Uic()
env.Uic()
```

Builds a header file, an implementation file and a moc file from an ui file, and returns the corresponding nodes in the above order. This builder is only available after using the tool `qt`. Note: you can specify `.ui` files directly as source files to the `Program`, `Library` and `SharedLibrary` builders without using this builder. Using this builder lets you override the standard naming conventions (be careful: prefixes are always prepended to names of built files; if you don’t want prefixes, you may set them to "."). See the `$SQTDIR` variable for more information. Example:

```python
env.Uic('foo.ui') # -> ['foo.h', 'uic_foo.cc', 'moc_foo.cc']
env.Uic(target = Split('include/foo.h gen/uicfoo.cc gen/mocfoo.cc'),
        source = 'foo.ui') # -> ['include/foo.h', 'gen/uicfoo.cc', 'gen/mocfoo.cc']
```

```python
Zip()
env.Zip()
```

Builds a zip archive of the specified files and/or directories. Unlike most builder methods, the `Zip` builder method may be called multiple times for a given target; each additional call adds to the list of entries that will be built into the archive. Any source directories will be scanned for changes to any on-disk files, regardless of whether or not `scons` knows about them from other Builder or function calls.

```python
env.Zip('src.zip', 'src')

# Create the stuff.zip file.
env.Zip('stuff', ['subdir1', 'subdir2'])
# Also add "another" to the stuff.tar file.
env.Zip('stuff', 'another')
```
Appendix C. Tools

This appendix contains descriptions of all of the Tools modules that are available "out of the box" in this version of SCons.

386asm
Sets construction variables for the 386ASM assembler for the Phar Lap ETS embedded operating system.

Sets: $AS, $ASCOM, $ASFLAGS, $ASPPCOM, $ASPPFLAGS.
Uses: $CC, $CPPFLAGS, $_CPPDEFFLAGS, $_CPPINCFLAGS.

aixc++
Sets construction variables for the IMB xlc / Visual Age C++ compiler.

Sets: $CXX, $CXXVERSION, $SHCXX, $SHOBSUFFIX.

aixcc
Sets construction variables for the IBM xlc / Visual Age C compiler.

Sets: $CC, $CCVERSION, $SHCC.

aixf77
Sets construction variables for the IBM Visual Age f77 Fortran compiler.

Sets: $F77, $SHF77.

aixlink
Sets construction variables for the IBM Visual Age linker.

Sets: $LINKFLAGS, $SHLIBSUFFIX, $SHLINKFLAGS.

applelink
Sets construction variables for the Apple linker (similar to the GNU linker).
Appendix C. Tools

Sets: $FRAMEWORKPATHPREFIX, $LDMODULECOM, $LDMODULEFLAGS, $LDMODULEPREFIX, $LDMODULESUFFIX, $LINKCOM, $SHLINKCOM, $SHLINKFLAGS, $_FRAMEWORKPATH, $_FRAMEWORKS.

Uses: $FRAMEWORKSFLAGS.

ar
Sets construction variables for the ar library archiver.

Sets: $AR, $ARCOM, $ARFLAGS, $LIBPREFIX, $LIBSUFFIX, $RANLIB, $RANLIBCOM, $RANLIBFLAGS.

as
Sets construction variables for the as assembler.

Sets: $AS, $ASCOM, $ASFLAGS, $ASPPCOM, $ASPPFLAGS.

Uses: $CC, $CPPFLAGS, $_CPPDEFFLAGS, $_CPPINCFLAGS.

bcc32
Sets construction variables for the bcc32 compiler.

Sets: $CC, $CCCOM, $CCFLAGS, $CFILESUFFIX, $CFLAGS, $CPPDEFPREFIX, $CPPDEFSUFFIX, $INCPREFIX, $INCSUFFIX, $SHCC, $SHCCCOM, $SHCCFLAGS, $SHCFLAGS, $SHOBJSUFFIX.

Uses: $_CPPDEFFLAGS, $_CPPINCFLAGS.

BitKeeper
Sets construction variables for the BitKeeper source code control system.

Sets: $BITKEEPER, $BITKEEPERCOM, $BITKEEPERGET, $BITKEEPERGETFLAGS.

Uses: $BITKEEPERCOMSTR.

cc
Sets construction variables for generic POSIX C compilers.
Appendix C. Tools

Sets: $CC, $CCCOM, $CCFLAGS, $CFILESUFFIX, $CFLAGS, $CPPDEFPREFIX, $CPPDEFSUFFIX, $FRAMEWORKPATH, $FRAMEWORKS, $INCPREFIX, $INCSUFFIX, $SHCC, $SHCCCOM, $SHCCFLAGS, $SHCFLAGS, $SHOBSUFFIX.

Uses: $PLATFORM.

cvf
Sets construction variables for the Compaq Visual Fortran compiler.

Sets: $FORTRAN, $FORTRANCOM, $FORTRANMODDIR, $FORTRANMODDIRPREFIX, $FORTRANMODDIRSUFFIX, $FORTRANPPCOM, $OBJSUFFIX, $SHFORTRANCOM, $SHFORTRANPPCOM.

Uses: $CPPFLAGS, $FORTRANFLAGS, $SHFORTRANFLAGS, $_CPPDEFFLAGS, $_FORTRANINCFLAGS, $_FORTRANMODFLAG.

CVS
Sets construction variables for the CVS source code management system.

Sets: $CVS, $CVSCOFLAGS, $CVSCOM, $CVSFLAGS.

Uses: $CVSCOMSTR.

cXX
Sets construction variables for generic POSIX C++ compilers.

Sets: $CPPDEFPREFIX, $CPPDEFSUFFIX, $CXX, $CXXCOM, $CXXFILESUFFIX, $CXXFLAGS, $INCPREFIX, $INCSUFFIX, $OBJSUFFIX, $SHCXX, $SHCXXCOM, $SHCXXFILESUFFIX, $SHOBSUFFIX.

Uses: $CXXCOMSTR.

default
Sets variables by calling a default list of Tool modules for the platform on which SCons is running.

dmd
Sets construction variables for D language compilers (the Digital Mars D compiler, or GDC).


**dvi**

Attaches the DVI builder to the construction environment.

**dvipdf**

Sets construction variables for the dvipdf utility.

Sets: $DVIPDF, $DVIPDFCOM, $DVIPDFFLAGS.

Uses: $DVIPDFCOMSTR.

**dvips**

Sets construction variables for the dvips utility.

Sets: $DVIPS, $DVIPSFLAGS, $SPCOM, $SPPREFIX, $SPSUFFIX.

Uses: $SPCOMSTR.

**f77**

Set construction variables for generic POSIX Fortran 77 compilers.

Sets: $F77, $F77COM, $F77FILESUFFIXES, $F77FLAGS, $F77PPCOM, $F77PPFILESUFFIXES, $FORTRAN, $FORTRANCOM, $FORTRANFLAGS, $SHF77, $SHF77COM, $SHF77FLAGS, $SHF77PPCOM, $SHFORTRAN, $SHFORTRANCOM, $SHFORTRANFLAGS, $SHFORTRANPPCOM, $_F77INCFLAGS.

Uses: $F77COMSTR, $F77PPCOMSTR, $FORTRANCOMSTR, $FORTRANPPCOMSTR, $SHF77COMSTR, $SHF77PPCOMSTR, $SHFORTRANCOMSTR, $SHFORTRANPPCOMSTR.

**f90**

Set construction variables for generic POSIX Fortran 90 compilers.

Sets: $F90, $F90COM, $F90FLAGS, $F90PPCOM, $SHF90, $SHF90COM, $SHF90FLAGS, $SHF90PPCOM, $_F90INCFLAGS.

Uses: $F90COMSTR, $F90PPCOMSTR, $SHF90COMSTR, $SHF90PPCOMSTR.

**f95**

Set construction variables for generic POSIX Fortran 95 compilers.
Appendix C. Tools

Sets: $F95, $F95COM, $F95FLAGS, $F95PPCOM, $SHF95, $SHF95COM, $SHF95FLAGS, $SHF95PPCOM, ${_F95INCFLAGS}.

Uses: $F95COMSTR, $F95PPCOMSTR, $SHF95COMSTR, $SHF95PPCOMSTR.

**fortran**

Set construction variables for generic POSIX Fortran compilers.

Sets: $FORTRAN, $FORTRANCOM, $FORTRANFLAGS, $SHFORTRAN, $SHFORTRANCOM, $SHFORTRANFLAGS, $SHFORTRANPPCOM.

Uses: $FORTRANCOMSTR, $FORTRANPPCOMSTR, $SHFORTRANCOMSTR, $SHFORTRANPPCOMSTR.

**g++**

Set construction variables for the gXX C++ compiler.

Sets: $CXX, $CXXVERSION, $SHCXXFLAGS, $SHOBJSUFFIX.

**g77**

Set construction variables for the g77 Fortran compiler. Calls the $f77 Tool module to set variables.

**gas**

Sets construction variables for the gas assembler. Calls the as module.

Sets: $AS.

**gcc**

Set construction variables for the gcc C compiler.

Sets: $CC, $CCVERSION, $SHCCFLAGS.

**gnulink**

Set construction variables for GNU linker/loader.

Sets: $SRPATHPREFIX, $SRPATHSUFFIX, $SRLINKFLAGS.
Appendix C. Tools

**gs**
Set construction variables for Ghostscript.

Sets: `$GS`, `$GSCOM`, `$GSFLAGS`.

Uses: `$GSCOMSTR`.

**hpc++**
Set construction variables for the compilers aCC on HP/UX systems.

**hpcc**
Set construction variables for the aCC on HP/UX systems. Calls the `cXX` tool for additional variables.

Sets: `$CXX`, `$CXXVERSION`, `$SHCXXFLAGS`.

**hplink**
Sets construction variables for the linker on HP/UX systems.

Sets: `$LINKFLAGS`, `$SHLIBSUFFIX`, `$SHLINKFLAGS`.

**icc**
Sets construction variables for the icc compiler on OS/2 systems.

Sets: `$CC`, `$CCCOM`, `$CFILESUFFIX`, `$CPPDEFPREFIX`, `$CPPDEFSUFFIX`, `$CXXCOM`, `$CXXFILESUFFIX`, `$INCPREFIX`, `$INCSUFFIX`.

Uses: `$CCFLAGS`, `$CFLAGS`, `$CPPFLAGS`, `_CPPDEFFLAGS`, `_CPPINCFLAGS`.

**icl**
Sets construction variables for the Intel C/C++ compiler. Calls the `intelor` Tool module to set its variables.

**ifl**
Sets construction variables for the Intel Fortran compiler.

Sets: `$FORTRAN`, `$FORTRANCOM`, `$FORTRANPPCOM`, `$SHFORTRANCOM`, `$SHFORTRANPPCOM`. 
Appendix C. Tools

Uses: $CPPFLAGS, $FORTRANFLAGS, $_CPPDEFFLAGS, $_FORTRANINCFLAGS.

ifort
Sets construction variables for newer versions of the Intel Fortran compiler for Linux.

Sets: $F77, $F90, $F95, $FORTRAN, $$SHF77, $$SHF77FLAGS, $$SHF90, $$SHF90FLAGS, $$SHF95, $$SHF95FLAGS, $$SHFORTRAN, $$SHFORTRANFLAGS.

ilink
Sets construction variables for the ilink linker on OS/2 systems.

Sets: $LIBDIRPREFIX, $LIBDIRSUFFIX, $LIBLINKPREFIX, $LIBLINKSUFFIX, $LINK, $LINKCOM, $LINKFLAGS.

ilink32
Sets construction variables for the Borland ilink32 linker.

Sets: $LIBDIRPREFIX, $LIBDIRSUFFIX, $LIBLINKPREFIX, $LIBLINKSUFFIX, $LINK, $LINKCOM, $LINKFLAGS.

install
Sets construction variables for file and directory installation.

Sets: $INSTALL, $INSTALLSTR.

intelc
Sets construction variables for the Intel C/C++ compiler (Linux and Windows, version 7 and later). Calls the gcc or msvc (on Linux and Windows, respectively) to set underlying variables.

Sets: $AR, $CC, $CXX, $INTEL_C_COMPILER_VERSION, $LINK.

jar
Sets construction variables for the jar utility.

Sets: $JAR, $JARCOM, $JARFLAGS, $JARSUFFIX.
Appendix C. Tools

**javadoc**

Sets construction variables for the javac compiler.

Sets: $JAVABOOTCLASSPATH, $JAVAC, $JAVACCOM, $JAVACFLAGS, $JAVACLASSPATH, $JAVACLASSSSUFFIX, $JAVA.currentPage$SOURCEPATH, $JAVAcurrentPage$SUFFIX.

Uses: $JAVACcurrentPage$OMSTR.

**javah**

Sets construction variables for the javah tool.

Sets: $JAVAcurrentPage$CLASSSSUFFIX, $JAVAcurrentPage$, $JAVAcurrentPage$COM, $JAVAcurrentPage$FLAGS.

Uses: $JAVAcurrentPage$CLASSPATH, $JAVAcurrentPage$COMSTR.

**latex**

Sets construction variables for the latex utility.

Sets: $LATEX, $LATEXCOM, $LATEXFLAGS.

Uses: $LATEXcurrentPage$OMSTR.

**lex**

Sets construction variables for the lex lexical analyser.

Sets: $LEX, $LEXCOM, $LEXFLAGS.

Uses: $LEXcurrentPage$OMSTR.

**link**

Sets construction variables for generic POSIX linkers.

Appendix C. Tools

SLIBLINKSUFFIX, $LINK, $LINKCOM, $LINKFLAGS, $SHLIBSUFFIX, $SHLINK, $SHLINKCOM, $SHLINKFLAGS.

Uses: $LDMODULECOMSTR, $LINKCOMSTR, $SHLINKCOMSTR.

linkloc

Sets construction variables for the LinkLoc linker for the Phar Lap ETS embedded operating system.

Sets: $LIBDIRPREFIX, $LIBDIRSUFFIX, $LIBLINKPREFIX, $LIBLINKSUFFIX, $LINK, $LINKCOM, $LINKFLAGS, $SHLINK, $SHLINKCOM, $SHLINKFLAGS.

Uses: $LINKCOMSTR, $SHLINKCOMSTR.

m4

Sets construction variables for the m4 macro processor.

Sets: $M4, $M4COM, $M4FLAGS.

Uses: $M4COMSTR.

masm

Sets construction variables for the Microsoft assembler.

Sets: $AS, $ASCOM, $ASFLAGS, $ASPPCOM, $ASPPFLAGS.

Uses: $ASCOMSTR, $ASPPCOMSTR, $CPPFLAGS, $CPPDEFFLAGS, $CPPINCFLAGS.

midl

Sets construction variables for the Microsoft IDL compiler.

Sets: $MIDL, $MIDLCOM, $MIDLFLAGS.

Uses: $MIDLCOMSTR.
Appendix C. Tools

mingw

Sets construction variables for MinGW (Minimal Gnu on Windows).

Sets: $AS, $CC, $CXX, $LDMODULECOM, $LIBPREFIX, $LIBSUFFIX, $OBJPREFIX, $OBJSUFFIX, $SRC,
SRC.COM, $RCFLAGS, $RCINCPREFIX, $RCINCSUFFIX, $SHCCFLAGS, $SHCXXFLAGS, $SHLINKCOM, $SHLINKFLAGS, $SHOBJSUFFIX,
$WINDOWSDEFPREFIX, $WINDOWSDEFSUFFIX.

Uses: $RCCOMSTR, $SHLINKCOMSTR.

mslib

Sets construction variables for the Microsoft mslib library archiver.

Sets: $AR, $ARCOM, $ARFLAGS, $LIBPREFIX, $LIBSUFFIX.

Uses: $ARCOMSTR.

mslink

Sets construction variables for the Microsoft linker.

Sets: $LDMODULE, $LDMODULECOM, $LDMODULEFLAGS, $LDMODULEPREFIX, $LDMODULESUFFIX, $LIBPREFIX, $LIBSUFFIX, $LIBLINKPREFIX,
$LIBLINKSUFFIX, $LINK, $LINKCOM, $LINKFLAGS, $REGSVR, $REGSVRCOM,
$REGSVRFLAGS, $SHLINK, $SHLINKCOM, $SHLINKFLAGS, $WIN32DEFPREFIX, $WIN32DEFSUFFIX, $WIN32EXPREFIX, $WIN32EXPSUFFIX, $WINDOWSDEFPREFIX,
$WINDOWSDEFSUFFIX, $WINDOWSDEFSUFFIX, $WINDOWSEXPPREFIX, $WINDOWSEXPSUFFIX,
$WINDOWSSPROGMANIFESTPREFIX, $WINDOWSSPROGMANIFESTSUFFIX,
$WINDOWSSHLIBMANIFESTPREFIX, $WINDOWSSHLIBMANIFESTSUFFIX,
$WINDOWS_INSERT_DEF.

Uses: $LDMODULECOMSTR, $LINKCOMSTR, $MSVS_IGNORE_IDE_PATHS,
$REGSVRCOMSTR, $SHLINKCOMSTR.

msvc

Sets construction variables for the Microsoft Visual C/C++ compiler.

Sets: $BUILDERS, $CC, $CCCOM, $CCFLAGS, $CCPCHFLAGS, $CCPDBFLAGS,
$FILESUFFIX, $FLAGS, $CPPDEFPREFIX, $CPPDEFSUFFIX, $CXX, $CXXCOM,
$CXXFILESUFFIX, $CXXFLAGS, $INCPREFIX, $INCSUFFIX, $OBJPREFIX, $OBJSUFFIX,
$PCHCOM, $PCHPDBFLAGS, $SRC, $SRC.COM, $SRCFLAGS, $SH, $SHCCOM,
Appendix C. Tools

$SHCCFLAGS, $SHCFLAGS, $SHCXX, $SHCXXCOM, $SHCXXFLAGS, $SHOBJPREFIX, $SHOBJSUFFIX.

Uses: $CCCOMSTR, $CXXCOMSTR, $SHCCCOMSTR, $SHCXXCOMSTR.

**msvs**

Sets construction variables for Microsoft Visual Studio.

Sets: $MSVSBUILDCOM, $MSVSCLEANCOM, $MSVSENCODING, $MSVSPROJECTCOM, $MSVSREBUILDCOM, $MSVSSCONS, $MSVSSCONSCOM, $MSVSSCONSCRIPT, $MSVSSCONSFLAGS, $MSVSSOLUTIONCOM.

**mwcc**

Sets construction variables for the Metrowerks CodeWarrior compiler.

Sets: $CC, $CCCOM, $CFILESUFFIX, $CPPDEFPREFIX, $CPPDEFSUFFIX, $CXX, $CXXCOM, $CXXFILESUFFIX, $INCPREFIX, $INCSUFFIX, $MWCW_VERSION, $MWCW_VERSIONS, $SHCC, $SHCCCOM, $SHCCFLAGS, $SHCFLAGS, $SHCXX, $SHCXXCOM, $SHCXXFLAGS.

Uses: $CCCOMSTR, $CXXCOMSTR, $SHCCCOMSTR, $SHCXXCOMSTR.

**mwld**

Sets construction variables for the Metrowerks CodeWarrior linker.

Sets: $AR, $ARCOM, $LIBDIRPREFIX, $LIBDIRSUFFIX, $LIBLINKPREFIX, $LIBLINKSUFFIX, $LINK, $LINKCOM, $SHLINK, $SHLINKCOM, $SHLINKFLAGS.

**nasm**

Sets construction variables for the nasm Netwide Assembler.

Sets: $AS, $ASCOM, $ASFLAGS, $ASPPCOM, $ASPPFLAGS.

Uses: $ASCOMSTR, $ASPPCOMSTR.

**packaging**

A framework for building binary and source packages.
Appendix C. Tools

Packaging

Sets construction variables for the Package Builder.

pdf

Sets construction variables for the Portable Document Format builder.

Sets: $PDFPREFIX, $PDFSUFFIX.

pdflatex

Sets construction variables for the pdflatex utility.

Sets: $LATEXRETRIES, $PDFLATEX, $PDFLATEXCOM, $PDFLATEXFLAGS.

Uses: $PDFLATEXCOMSTR.

pdftex

Sets construction variables for the pdftex utility.

Sets: $LATEXRETRIES, $PDFTEX, $PDFTEXCOM, $PDFTEXFLAGS, $PDFTEX,
$PDFTEXCOM, $PDFTEXFLAGS.

Uses: $PDFTEXCOMSTR, $PDFTEXCOMSTR.

Perforce

Sets construction variables for interacting with the Perforce source code management system.

Sets: $P4, $P4COM, $P4FLAGS.

Uses: $P4COMSTR.

qt

Sets construction variables for building Qt applications.

Sets: $QTDIR, $QT_AUTOSCAN, $QT_BINPATH, $QT_CPPPATH, $QT_LIB, $QT_LIBPATH,
$QT_MOC, $QT_MOCXXXPREFIX, $QT_MOCXXXSUFFIX, $QT_MOCFROMCXXCOM,
$QT_MOCFROMCXXFLAGS, $QT_MOCFROMHCOM, $QT_MOCFROMHFLAGS,
$QT_MOCPREFIX, $QT_MOCHPREFIX, $QT_MOCHSUFFIX, $QT_UIC, $QT_UICC, $QT_UICDECLFLAGS,
$QT_UICDECLPREFIX, $QT_UICDECLSUFFIX, $QT_UICIMPLEFLAGS,
$QT_UICIMPLPREFIX, $QT_UICIMPLSUFFIX, $QT_UISUFFIX.

RCS
Sets construction variables for the interaction with the Revision Control System.

Sets: $RCS, $RCS_CO, $RCS_COCOM, $RCS_COFLAGS.

Uses: $RCS_COCOMSTR.

rmic
Sets construction variables for the rmic utility.

Sets: $JAVACLASSSUFFIX, $RMIC, $RMICCOM, $RMICFLAGS.

Uses: $RMICCOMSTR.

rpcgen
Sets construction variables for building with RPCGEN.

Sets: $RPCGEN, $RPCGENCLIENTFLAGS, $RPCGENFLAGS, $RPCGENHEADERFLAGS,
$RPCGENSERVICEFLAGS, $RPCGENXDRFLAGS.

SCCS
Sets construction variables for interacting with the Source Code Control System.

Sets: $SCCS, $SCCCOM, $SCCSFLAGS, $SCCSGETFLAGS.

Uses: $SCCCCOMSTR.

sgiar
Sets construction variables for the SGI library archiver.

Sets: $AR, $ARCOMSTR, $ARFLAGS, $LIBPREFIX, $LIBSUFFIX, $SHLINK,
$SHLINKFLAGS.

Uses: $ARCOMSTR, $SHLINKCOMSTR.
Appendix C. Tools

sgic++
Sets construction variables for the SGI C++ compiler.

Sets: $CXX, $CXXFLAGS, $SHCXX, $SHOBJSUFFIX.

sgicc
Sets construction variables for the SGI C compiler.

Sets: $CXX, $SHOBJSUFFIX.

sgilink
Sets construction variables for the SGI linker.

Sets: $LINK, $RPATHPREFIX, $RPATHSUFFIX, $SHLINKFLAGS.

sunar
Sets construction variables for the Sun library archiver.

Sets: $AR, $ARCOM, $ARFLAGS, $LIBPREFIX, $LIBSUFFIX, $SHLINK, $SHLINKCOM, $SHLINKFLAGS.

Uses: $ARCOMSTR, $SHLINKCOMSTR.

sunc++
Sets construction variables for the Sun C++ compiler.

Sets: $CXX, $CXXVERSION, $SHCXX, $SHCXXFLAGS, $SHOBJPREFIX, $SHOBJSUFFIX.

suncc
Sets construction variables for the Sun C compiler.

Sets: $CXX, $SHCCFLAGS, $SHOBJPREFIX, $SHOBJSUFFIX.
sunlink

Sets construction variables for the Sun linker.

Sets: $RPATHPREFIX, $RPATHSUFFIX, $SHLINKFLAGS.

swig

Sets construction variables for the SWIG interface generator.

Sets: $SWIG, $SWIGCFFILESUFFIX, $SWIGCOM, $SWIGCXXFILESUFFIX, $SWIGFLAGS, $SWIGINCPREFIX, $SWIGINCSUFFIX, $SWIGPATH, $SWIGINCFLAGS.

Uses: $SWIGCOMSTR.

tar

Sets construction variables for the tar archiver.

Sets: $STAR, $STARCOM, $STARFLAGS, $STARSUFFIX.

Uses: $STARCOMSTR.

tex

Sets construction variables for the TeX formatter and typesetter.

Sets: $BIBTEX, $BIBTEXCOM, $BIBTEXFLAGS, $LATEX, $LATEXCOM, $LATEXFLAGS, $MAKEINDEX, $MAKEINDEXCOM, $MAKEINDEXFLAGS, $TEX, $TEXCOM, $TEXFLAGS.

Uses: $BIBTEXCOMSTR, $LATEXCOMSTR, $MAKEINDEXCOMSTR, $TEXCOMSTR.

tlib

Sets construction variables for the Borlan tib library archiver.

Sets: $AR, $ARCOM, $ARFLAGS, $SLIBPREFIX, $SLIBSUFFIX.

Uses: $ARCOMSTR.
Appendix C. Tools

yacc

Sets construction variables for the yacc parse generator.

Sets: $YACC, $YACCCOM, $YACCFLAGS, $YACCHFILESUFFIX, $YACCHXXFILESUFFIX, $YACCVCFILESUFFIX.

Uses: $YACCCOMSTR.

zip

Sets construction variables for the zip archiver.

Sets: $ZIP, $ZIPCOM, $ZIPCOMPRESSION, $ZIPFLAGS, $ZIPSUFFIX.

Uses: $ZIPCOMSTR.
Appendix D. Handling Common Tasks

There is a common set of simple tasks that many build configurations rely on as they become more complex. Most build tools have special purpose constructs for performing these tasks, but since SConscript files are Python scripts, you can use more flexible built-in Python services to perform these tasks. This appendix lists a number of these tasks and how to implement them in Python.

Example D-1. Wildcard globbing to create a list of filenames

```python
import glob
files = glob.glob(wildcard)
```

Example D-2. Filename extension substitution

```python
import os.path
filename = os.path.splitext(filename)[0]+extension
```

Example D-3. Appending a path prefix to a list of filenames

```python
import os.path
filenames = [os.path.join(prefix, x) for x in filenames]
```

or in Python 1.5.2:

```python
import os.path
new_filenames = []
for x in filenames:
    new_filenames.append(os.path.join(prefix, x))
```

Example D-4. Substituting a path prefix with another one

```python
if filename.find(old_prefix) == 0:
    filename = filename.replace(old_prefix, new_prefix)
```

or in Python 1.5.2:

```python
import string
if string.find(filename, old_prefix) == 0:
    filename = string.replace(filename, old_prefix, new_prefix)
```

Example D-5. Filtering a filename list to exclude/retain only a specific set of extensions

```python
import os.path
filenames = [x for x in filenames if os.path.splitext(x)[1] in extensions]
```

or in Python 1.5.2:

```python
import os.path
```
new_filenames = []
for x in filenames:
    if os.path.splitext(x)[1] in extensions:
        new_filenames.append(x)

Example D-6. The "backtick function": run a shell command and capture the output

import os
output = os.popen(command).read()