

# Release Notes — Gardens Point Component Pascal

## Version 1.2.0 for JVM (*September 2002*)

### 1. Introduction

Gardens Point Component Pascal (*gpcp*) is an implementation of the Component Pascal Language, as defined in the Component Pascal Report from Oberon Microsystems. It is intended that this be a faithful implementation of the report, except for those changes that are explicitly detailed here. Any other differences in detail should be reported as potential bugs.

The distribution consists of four programs, and a number of libraries. The programs are the compiler *gpcp*, the make utility *CPMake*, a module interface browser tool *Browse*, and a tool for producing interfaces from class files written in java, *J2CPS*. There will be other utilities added later.

The compiler produces either Microsoft.NET intermediate language or Java Virtual Machine (*JVM*) byte-codes as output. The compiler can be bootstrapped on either platform. These release notes refer to the Java byte-code (*JVM*) platform.

There are a number of syntactic extensions to the Component Pascal language accepted by the compiler which are introduced to allow interworking with the native libraries of the underlying platform. The guiding philosophy in such cases is to not significantly extend the semantics of the constructs that form part of Component Pascal, but rather to provide syntax for accessing features of other languages, which have no direct counterpart in Component Pascal.

### 2. Overall Structure

#### 2.1 Input and Output files

In normal usage the compiler creates two or more output files for every source file. If the file **Hello.cp** contains the module “Hello”, and is compiled, then the output files will be **Hello.cps** and **Hello.class**. The “\*.cps” file is the symbol file which contains the meta-information that describes the facilities exported from the module. The program executable will be “\*.class”. If the program defines other classes (i.e. the program defines record types) then there will be several other \*.class files. The class files will be placed in a subdirectory of the current directory named CP, so that the class loading mechanism of the JVM can find them. All other files are created in the current directory. If a listing file is created it will have extension “.lst”.

Be aware that the stem name of the output files comes from the *module* name, not from the source-file name. Thus if module “Foo” is in source file “Hello.cp” then all of the output files will have stem name “Foo”.

#### Creating class files

From release 0.95, *gpcp* writes class files directly, by default. Previous releases wrote **Jasmin** assembly \*.j files, and invoked the Jasmin byte code assembler. The direct writing of class files is much faster, but it is possible to force the compiler to use Jasmin. Of course, if you wish to do this, then you must install Jasmin on your system.

It is possible to invoke the compiler so as to produce just the intermediate language file, and then invoke the **jasmin** assembler manually. This allows the options of **jasmin** to be invoked so as to place the class files in other locations on the class path of your Java Runtime Environment. The same effect may be gained by using the **/clmdir** option from version 1.2.0.

## 2.2 Invoking the compiler

The compiler is invoked from the command line using the command

```
$> cprun gpcp [options] files←
```

where options include

<b>-copyright</b>	display the copyright notice
<b>-dostats</b>	emit timing and other statistics
<b>-help</b>	emit this usage prompt
<b>"-hsize=NNN"</b>	set hashtable size $\geq$ NNN (0 .. 65000)
<b>-jasmin</b>	do not create the class file directly, but use <b>jasmin</b>
<b>-list</b>	create an output listing if there are errors (default)
<b>-list+</b>	always create an output listing
<b>-list-</b>	never create an output listing
<b>-nocode</b>	create .j output, but do not assemble
<b>-noasm</b>	produce a symbol file, but no il
<b>-nosym</b>	produce no output files, not even a symbol file
<b>-strict</b>	disallow non-standard language constructs
<b>-special</b>	used for creating symbol files for foreign interfaces
<b>"-target=xxx"</b>	emit assembler output for platform "xxx"
<b>-verbose</b>	chatter on about progress during compilation
<b>-version</b>	emit version information
<b>-warn-</b>	suppress warning messages from the console
<b>-nowarn</b>	same as <b>-warn-</b>
<b>"-symdir=XXX"</b>	place symbol files in directory "xxx"
<b>"-clmdir=XXX"</b>	place class files in hierarchy rooted at "xxx"

Any number of files may be added in a white-space separated list. In the *JVM* version the option prefix '-' form is the expected default. The *.NET* version accepts either "/" or "-" as an option prefix.

## 2.3 The cprun script

**cprun** is a batch or shell file which invokes the Java runtime. There is a corresponding script **cpint** which invokes the runtime without using the just-in-time compiler. Both of these scripts are in the **/gpcp/bin** directory.

The compiler may be run without using the script by directly invoking the Java runtime. A typical command would be –

```
$> java [java-options] CP.gpcp.gpcp [options] files
```

The java options set any needed properties, define the classpath, and choose the JIT options. **CP.gpcp.gpcp** is the full name of the class that contains the compiler entry point.

## 2.4 Target choice

The compiler may choose its output language at runtime. The default output when running on the JVM platform is to produce class files for the Java virtual machine. The recognized options are

<b>-target=net</b>	this is the default <i>.NET</i> virtual object system format
<b>-target=jvm</b>	this causes Java byte codes to be emitted
<b>-target=dcf</b>	this chooses the Gardens Point “d-code” form

The *dcf* format is not yet available, but is intended to access the Gardens Point native code generators on all the platforms for which Gardens Point Modula-2 is implemented.

### Output files

Running the compiler with the **-nosym** flag causes the input files to be parsed and type-checked, but no output files are created except possibly a listing file.

If the compiler is run with the **-noasm** flag, the input files are parsed and type-checked, and a symbol file is produced for each input file. No assembly language or class file output is produced however.

If the compiler is run with the **-nocode** flag, the input files are parsed and type-checked, and a symbol file and one or more Jasmin assembly language files are produced for each input file. No class files are produced in this case.

If the compiler is run without any flags, the input files are parsed and type-checked, and a symbol file and one or more class files are produced for each input file.

If the compiler is run with the **-jasmin** flag, the input files are parsed and type-checked, and a symbol file and one or more Jasmin assembly language files are produced for each input file. Following this, the Jasmin assembler will be automatically invoked to create the corresponding class files.

### Output files with **-target=net**

If the compiler is run with the **-target=net** flag, a Microsoft Intermediate Language (MSIL) file will be produced for each input file. Because the current version cannot run the MSIL assembler, even if it is installed, the compiler must in this case also be invoked with at least the **-nocode** flag.

## 2.5 Overflow checking

The *JVM* does not support overflow checking of arithmetic operations at a tolerable efficiency, so that no checks are done currently on this platform. Overflow checks are the default on the *.NET* platform, but compiling with the **/nocheck** option removes these. There is a very small speed gain if checks are turned off. Checks may also be turned off on a per-procedure basis, as described below.

## 2.6 Listing output

The compiler, by default produces a listing file only if there are compile-time errors or warnings. It is possible to force the compiler to produce a listing, using the **-list+**

option. Equally, it is possible to prevent the creation of a listing file even if there are errors, by using the `-list-` option.

The listing file contains the complete listing of the program, with four digit line numbers prepended. Errors are reported in the following format –

```
1  MODULE BarMod;
2      IMPORT
3          FooMod;
4      TYPE
5          Bar* = POINTER TO ABSTRACT RECORD (FooMod.Foo) END;
****      ^ Only ABSTRACT basetypes can have abstract extensions
6              i,j,k : INTEGER
7              END;
8  END BarMod.
```

## 2.7 Statistics output

If the compiler is invoked with option `-dostats` then compile time statistics are produced. Here is an example for the program *Browse*.

```
C:\gpcp\work> cprun gpcp -dostats Browse.cp
#gpcp: <Browse> No errors
#gpcp: jvm version 1.1.4 of 25 December 2001
#gpcp: 2165 source lines
#gpcp: import recursion depth 3
#gpcp: 795 entries in hashtable of size 4099
#gpcp: import time      130mSec
#gpcp: source time     170mSec
#gpcp: parse time      371mSec
#gpcp: analysis time   130mSec
#gpcp: symWrite time    20mSec
#gpcp: asmWrite time   631mSec
#gpcp: assemble time    0mSec
#gpcp: total time     1452mSec
C:\gpcp\work>
```

The meaning of the values written to the console is as follows.

- The compiler imports symbol files in dependency order, if necessary. The maximum recursion depth for this example turned out to be 3.
- The compiler allows choice of hashtable size. The number of entries used is shown
- Import time is the time to read and process metainformation for all imports. In the example *Browse* imports most of the compiler meta-information for *gpcp*.
- Source time is the time to read the source file into the internal buffer.
- Parse time is the time to parse the buffer, create the syntax tree and resolve all identifiers.
- Analysis time is the time to do type checking, and dataflow analysis.
- SymWrite time is the time to write out metatdata to the symbol file.
- AsmWrite time is the time to write out the assembly language (.j) output if the `-jasmin` option is used, or the byte codes (.class) file.

- Assemble time is the time taken to spawn a new process and run **jasmin** if the **-jasmin** option is used.

## 2.8 Setting the hash table size

The compiler uses closed hashing internally, with a default number of identifiers of 4099 in the current version. It is possible to increase the number of entries by means of the **-hsize=NUMBER** option. Numbers up to 66000 are meaningful to the program.

If the hash table overflows, the compiler gives an error message, with a hint to increase the size. There is an example program with the distribution that creates a program that will break the compiler, so that users may test this feature. The compilation fails with the default table, but succeeds with **-hsize=5000**.

## 2.9 Choosing the Output Directories

By default all output files are created in the current directory. This behavior may be overridden with the new options **/clmdir** and **/symdir**. The symbol file is placed in the directory specified by the option –

**/symdir=target-directory**

Note carefully that if a target directory is chosen that is not on the “CPSYM” path then **gpcp** will not be able to find the symbol files automatically.

Class files being created may be placed in a specified directory using the –

**/clmdir=target-directory**

option. This specifies the root directory for the class hierarchy. If this option is chosen, then the specified directory should be on the class path.

If the .NET target has been chosen then the “symdir” option still applies, but “clmdir” option does not. Instead, a similar option “bindir” specifies the output directory.

## 2.10 The Make utility

The compilation process with Component Pascal guarantees type safety across separately compiled module boundaries. Since interface meta-information resides in the symbol files which **gpcp** creates, modules must be compiled in an order that respects the partial order induced by the global importation graph. For complex programs, this may be difficult to determine manually.

The utility **CPMake** reads symbol files, and if necessary source files, in order to determine a valid order of compilation. The syntax for invocation is –

**\$> cprun CPMake [options] moduleName↵**

The module name may be given with or without a file-extension, but must be the name of a module which imports **CPMain**, that is, it must be a base module.

When source files of a program have been modified in general only a subset of the modules have to be recompiled. **CPMake** is able to work out which modules must be recompiled by checking the date stamps on the files, and also checking the module hash-keys (“magic numbers”) in the symbol files. If a module has been edited, but the public interface of the module has not changed a recompilation should compute a new magic number which is the same as that expected by any previously compiled, dependent modules. In this case **CPMake** detects that the dependent modules are still

consistent and do not require recompilation. This “domino-stopping” feature of the program ensures that a conservative minimum of modules is recompiled.

The options accepted by the program are exactly the options accepted by *gpcp*, except that the option **-all** forces compilation of all modules in the local directory irrespective of date stamps and magic numbers.

## 2.11 Class Interface Browser

The program *Browse* reads the symbol file of a module and displays the public interface. This public interface is shown in a form similar to a Component Pascal module. This “module” shows all the types, variables and procedures that are exported from the specified module. Only the exported fields of record types are shown. Any exported procedures are shown as procedure headers only. The output from *Browse* is **not** a proper Component Pascal module and will not compile using *gpcp*. It simply shows all of the identifiers that may be imported and used by a client module.

This program is invoked with the command

```
$> cprun Browse [options] moduleName↵
```

the symbol file extension .cps may, but need not, be included in the *moduleName*.

As with *gpcp*, any number of files may be added in a white-space separated list. The *Browse* program sends its output to the console by default, and has the following options:

<b>-all</b>	browse this and all imported modules
<b>-full</b>	display full foreign names
<b>-file</b>	write output to the file <i>&lt;moduleName&gt;.bro</i>
<b>-html</b>	write html output to the file <i>&lt;moduleName&gt;.html</i>

The **-all** option produces output for all of the modules on the global imports graph of the specified module. The **-full** option is only meaningful for FOREIGN modules where the output from *Browse* will include the full external names for all procedures. The default for *Browse* is to only display the internal (Component Pascal) names. See Section 7 for more on Foreign Language Interfaces. The **-file** option sends the output to the file *<moduleName>.bro* instead of to the console. The **-html** option produces hyperlinked html text in the file *<moduleName>.html*.

## 2.12 Symbol File Generator J2CPS

The *J2CPS* utility has been included with this release. This utility is used to produce gpcp symbol files for the java library packages. This allows Component Pascal programs to interface with java library classes. One symbol file is produced for each java package. The utility needs only to be run once on all the packages in your java libraries. If you update your version of java, then the utility should be run with the new library packages.

When supplied with a java package name, J2CPS reads the information about that package from the java class files and produces a gpcp symbol file. A symbol file will also be produced, where one does not already exist, for every package on the global imports graph.

The J2CPS utility is invoked as follows:

```
$> java J2CPS [options] <javaPackageName>↵
```

the *javaPackageName* is a fully qualified java package name (eg. java/lang). There are two options `-d dir` where *dir* is the directory that the symbol files will be written to (the default is the current directory) and `-v` for verbose diagnostics.

#### To run **J2CPS**

- (1) Unpack the class files. If the java library class files are already present in your version of java then you do not need to do this step. If not you will need to unpack the class files from the jar file. The file is called `rt.jar` in the `jre/lib` directory of your jdk.
- (2) Put the directory containing the class files on your path. You will need to edit the `j2cps` shell file or `j2cps.bat` file. Add the class file directory to the path under `-classpath` in this file.
- (3) You should now be able to run `j2cps`.

### 3. Lexical Issues

#### 3.1 Non-standard Keywords

In order to provide facilities for foreign language interfaces there are a total of six new keywords defined. These are all upper case names and cannot be used as program identifiers.

<b>DIV0</b>	- an additional arithmetic operator (C integer division)
<b>ENUM</b>	- used in dummy foreign modules in the <i>.NET</i> system
<b>INTERFACE</b>	- used in dummy foreign modules for defining interfaces
<b>REM0</b>	- an additional arithmetic operator (C integer remainder)
<b>RESCUE</b>	- used to mark a procedure-level exception catch block
<b>STATIC</b>	- used to declare static features in dummy foreign modules.

Only **DIV0**, **REM0** and **RESCUE** may be used in normal programs.

The following new predefined identifiers have been added. These can be redefined, but not at the outer lexical level. The definitions for these procedures are given below.

<b>MKSTR</b>	- function to convert a CP “string” to the native string type
<b>BOX</b>	- make a dynamically allocated copy of record or array
<b>THROW</b>	- procedure that (re)throws a native exception object
<b>TYPEOF</b>	- fetch the runtime type descriptor, for reflection etc.

There are some other predefined identifiers used in the extended syntax, but these are “context sensitive markers” and do not prevent the same names being used for program identifiers.

✓ *Remember, if you use any of these non-standard keywords or procedures, your program source will not be portable to other implementations of Component Pascal.*

#### 3.2 Fully qualified java package names

Fully qualified names in the Java Runtime Environment comprise three parts.

<b>Package name</b>	- this defines the directory in which the class exists
<b>Class name</b>	- the class name
<b>Feature name</b>	- the field or method name.

An example might be

```
java.lang.Exception.ToString
```

where **java.lang** is the package name, **Exception** is the class name, and **ToString** is a method name.

In this version of *gpcp*, the compiler produces one package per module. The package name is *CP.modulename*. Typically a module contains several classes. Fields and methods of types defined in the module have *JVM* class names that are formed by concatenating the module name and the type name. Thus a type-bound procedure called **isString()** bound to the type **UnaryX** in module **ExprDesc** would have the *JVM* name

```
CP.ExprDesc.ExprDesc_UnaryX.isString
```

Where *CP.ExprDesc* is the package name, and *ExprDesc\_UnaryX* is the mangled class name.

Procedures and variables at the module level are declared in the *JVM* as belonging to a synthetic “class” that contains only static data and code. This “**implicit static class**” has the same name as the module. Thus variable “x” in module *Foo* will have the somewhat boring *JVM* name

```
CP.Foo.Foo.x
```

Users of the compiler should almost never have to deal with explicit *JVM* names.

### 3.3 Identifier syntax

The identifier syntax for Component Pascal allows arbitrary use of the underscore (low-line) character. There is a further extension that is specific to the foreign language interface of *gpcp*.

Occasionally, names that are imported from foreign modules will happen to clash with CP reserved words. In this case, we may escape the reserve word detection by starting the identifier with the “back-quote” character ```. Thus, if an imported module has (say) a class with field named “**IF**”, then the field may be referenced as ``IF` in the source of your program. You may not *define* identifiers using this escape mechanism, except in foreign definition modules. You may however *refer* to imported identifiers using this mechanism.

It may be important to know that the back-quote is stripped at the time that the program is scanned. The presence of the escape simply suppresses the usual check for reserved identifiers that normally follows identifier scanning. Thus the back-quote is not used during any name matching of identifiers. A curious result of this strategy is that if a program escapes an identifier that does not need it, the escaped and non-escaped identifiers will refer to the same name.



## 4. Semantic Issues

### 4.1 Class files and entry points

The compiler produces one or more class files from each module which it compiles. Classes may be dynamically loaded, or may contain an entry point with the Java language signature

```
public static void main(java.lang.string[] args)
```

If the source file contains the import of the special name **CPmain**, then a class file containing an entry point is produced. In this case the module body becomes *main*, and begins with a hidden call that saves any command line arguments so that they may be accessed by calls to the *ProgArgs* library.

If the source file does not import **CPmain**, then the module body becomes the “class constructor” which is executed at the time that the class is dynamically loaded on demand.

If the compiler is run with the **-nocode** option, then only the assembler (**.j**) files are created. In this case the assembler *jasmin* may be explicitly invoked so as to create the class files.



**Important note on parameter semantics.**



*The JVM version of gpcp takes liberties with the precise semantics of parameter passing. Actual parameters of unboxed value type that are passed to reference formals are passed by copying. (Unboxed value types are the built-in standard types such as CHAR and INTEGER, together with the pointer types. Structures and arrays are always boxed at runtime in the JVM, and are not affected by this semantic modification.) In the case of formal parameters of VAR mode, actual values of unboxed value type are copied in and copied out. In the case of formal parameters of OUT mode the value is copied out. This change is necessary in order to obtain reasonable performance on the JVM. This change will not affect the results of your program unless you access the actual of a reference formal along two paths (either by having two reference formals sharing the same actual, or accessing a static variable directly and through a parameter. You should not write programs that do this! You might also care to know that with this change, the performance of code is good if you have only one such copied parameter, but becomes poor if you have more than one in any frequently called procedure..*



*This caution does not apply to the .NET or D-Code versions of gpcp. Both of these implement exact reference semantics.*

### 4.2 Unimplemented constructs

There are a small number of constructs that are unimplemented in this release of the compiler. These are –

- Procedure variables
- Non-local variable access

Both of these features were implemented in a prototype version of the compiler, but have been removed from this release. Each is somewhat inefficient, particularly on the **jvm** platform, and both are being considered for alternative implementation strategies.

As of this (1.2) version, non-local addressing is allowed, but procedure variables will have to wait for version 1.3 on the JVM platform. If compiling for the .NET platform procedure variables are implemented.

### 4.3 Additional Arithmetic Operators

The usual arithmetic operators **DIV** and **MOD** in Pascal-family languages have well defined semantics which are different from the division and remainder operators of implementations of C-family languages. In Component Pascal the operators **DIV** and **MOD** are defined as follows –

$$(i \text{ **DIV** } j) \times j + (i \text{ **MOD** } j) = i$$

$$i \text{ **DIV** } j = \lfloor i/j \rfloor; \text{ where } i, j \text{ are integers, and } i/j \text{ denotes real division.}$$

Notice that **DIV** always rounds toward negative infinity unlike most C-language implementations (which normally round towards zero). The Pascal operators are mathematically preferred, but in case the alternative semantics are required for compatibility reasons, **gpcp** introduces alternatives. **DIV0** denotes integer division with rounding toward zero, while **REMO** denotes the corresponding remainder operation.

☑ *Remember, if you use these non-standard operators, your program source will not be portable to other implementations of Component Pascal.*

### 4.4 Semantics of the WITH statement

The semantics of the WITH statement have been slightly modified so as to strengthen the guarantees on the properties of the selected variable. In the code

```
WITH x : TypeTi DO
    ... <guarded region>
| x : TypeTj DO
    ... <guarded region>
END;
```

the variable *x* is asserted to have the specified type throughout the so-called guarded region. The base language guarantees that the type of the selected variable cannot be widened in the guarded region, but might possibly be narrowed. In **gpcp** the selected variable is treated as a constant, and neither the type nor the value can be modified either directly or indirectly. Any attempt to do so attracts a compile-time error message.

### 4.5 Implementing foreign interfaces

Component Pascal types may extend Java classes. Types which extend Java classes may also declare that they implement interfaces. The syntax extension to access this feature is-

```
RecordDecl ::-      RECORD [BaseType] [Fields] END;
BaseType ::-        “[“ QualifiedIdent { “+” QualifiedIdent } “]”
```

The first qualified identifier, as in the *Report*, is the class that is extended by the type being defined. Any additional qualified identifiers are the names of interfaces that the type promises to implement. The compiler checks that this contract is honored. In the case that interfaces are implemented, the base type may be left blank, or may be explicitly set to **ANYREC**.

The semantics of type casts are also relaxed whenever a reference is cast to an imported interface type. For non-interface types many erroneous casts can be detected at compile time, but for interfaces no cast of an object of a foreign type can be rejected at compile time.

It is not possible to *define* interface types in Component Pascal.

#### 4.6 Unsigned byte type in .NET version

In the .NET version, as of 1.2.0, an unsigned byte type is supported, for compatibility with libraries that support the *Common Language Specification*. This type is not currently supported on the JVM platform.

#### 4.7 Runtime type descriptors

A new function in this release returns the runtime type descriptor. This allows easy access to the facilities of the reflection libraries. The function is overloaded, and has the following signatures –

```
PROCEDURE TYPEOF(typename) : RTS.NativeType;  
PROCEDURE TYPEOF(IN s : anytype) : RTS.NativeType;
```

If the target is the JVM, then *NativeType* will be `java.lang.Class` on the underlying runtime. If the target is .NET, the return type will be `System.Type`.

The first version takes any type name as actual parameter. The second version takes an actual parameter that is any variable designator. If the type of the designator is statically known (perhaps because it denotes an object of an inextensible type) then the compiler resolves the reference and no call is made to the runtime function `java.lang.Object::getClass()`.

#### 4.8 Additional built-in functions

There are three additional built-in functions added to the implementation. One allows convenient access to the underlying native string object type. The signature is –

```
PROCEDURE MKSTR(IN s : ARRAY OF CHAR) : RTS.NativeString;
```

☑ *Note that it is never necessary to use MKSTR when passing a literal string to a formal parameter of native string type. In the literal case the compiler does the conversion for the programmer automatically.*

Another handy function takes a record or array type, and makes a value copy onto the heap, returning a pointer to the copy. The signature is –

```
PROCEDURE BOX(s : T) : POINTER TO T;
```

Where T is a record, array or string type. The function copies the value so that modification of the boxed value does not affect the original. The function is particularly convenient for programs that manipulate character data implemented as dynamically allocated arrays. Thus `BOX("hello")` returns a pointer to array of char of length 6, while `BOX(ptr1^ + ptr2^)` performs a concatenation and allocates a destination array of the required length. If the function is applied to an array of fixed length the return value is an open array of the same length. In the case of character arrays the use of the array stringifier mark "\$" truncates the value at the first nul character, as usual.

Without this function, the construction of a value copy of an open array requires the following tedious construction –

```
VAR a,b : POINTER TO ARRAY OF CHAR;
...
NEW(b, LEN(a));
FOR i := 0 TO LEN(a) DO b[i] := a[i] END;
```

Using the new function, this simply becomes `b := BOX(a^);`

The final new built-in function, `THROW`, allows programs to throw exceptions, and is described below.

#### 4.9 Deprecated features and warnings

The use of procedure variables and super-calls are deprecated. Both attract compile-time warning messages. Warnings are also issued in the case of procedures that are not exported, and are not called within their defining module. This situation is usually an error arising from failure to mark the procedure for export.

#### 4.10 Program executable verification

Component Pascal is a type-safe language. Every correct program is type-safe in the same sense that is guaranteed by the Java verifier. In principle therefore, all output of *gpcp* should be verifiable.

You may force the Java runtime to verify your classes on loading by invoking the program from the command line with `java -verify` together with any other options.

Classes might fail to verify if a manually constructed interface to a library does not correspond to the meta-information in the imported class files. This potential problem has largely gone away with the use of **J2CPS**.

#### 4.11 Unchecked arithmetic

The *JVM* version of the compiler does not encode overflow checking, but this is the default for the *NET* version. If you want to write code that is portable between the two versions, then you should turn off overflow checking in those procedures that require this, by using a custom attribute.

The syntax of the custom attribute is a context sensitive marker that appears immediately after the keyword **BEGIN** in a procedure or module body. The syntax is –

```
Body → BEGIN [ “[ “UNCHECKED_ARITHMETIC” ” ] ” ]
        StatementSequence END identifier .
```

An example of the use of this construct, from the source of the compiler itself, is the identifier hash function –

```
PROCEDURE hashStr(IN str : ARRAY OF CHAR) : INTEGER;
  VAR tot : INTEGER;
      idx : INTEGER;
      len : INTEGER;
BEGIN [UNCHECKED_ARITHMETIC]
  len := LEN(str$);
  tot := 0;
  FOR idx := 0 TO len-1 DO
    INC(tot, tot);
    IF tot < 0 THEN INC(tot) END;
    INC(tot, ORD(str[idx]));
  END;
  RETURN tot MOD size;
END hashStr;
```

This function performs a rotate-and-add computation, in which bits are carried out of the sign bit back into the least significant bit of the variable *tot*. Overflow checking must be turned off, in order to prevent very long identifiers from crashing the compiler.

## 5. Exception Handling

Component Pascal does not define exception handling, but it is necessary to deal with foreign libraries that may throw exceptions. There is one new keyword and one new builtin procedure introduced to facilitate this.

### 5.1 The RESCUE clause

Procedures, but not modules may include exactly one *RESCUE* clause, at the end of the procedure body. This has syntax –

ProcBody → **BEGIN** Statements [**RESCUE** ‘(‘ ident ‘)’ Statements] **END** ident.

The identifier introduced in the parentheses is of type **RTS.NativeException**, and must have a name that is distinct from every other identifier in the local scope.

If any exception is thrown in the body of the procedure, or if any exception is unhandled in a procedure called from this procedure, then the rescue clause is entered with the exception object in the named local variable. This variable is read-only within the rescue clause, and is not known in the rest of the procedure body.

If the program has imported or defined any extensions of the native exception type, filtering may be performed by using the usual type-test syntaxes. The compiler will check that the rescue clause fulfills any contracts implied by the procedure signature. For example, in the case of function procedures the rescue clause must explicitly return a type-correct value, or explicitly throw another exception.

### 5.2 The THROW procedure

Code may throw an exception by using the built-in procedure **THROW**. This procedure has two signatures –

```
PROCEDURE THROW(x : RTS.NativeException);
PROCEDURE THROW(x : RTS.NativeString);
```

This may be used anywhere in the program, but is most useful for rethrowing an exception from within a rescue clause.

✓ *Remember, if you use these non-standard facilities for exception handling your program source will not be portable to other implementations of Component Pascal. Of course it will still be portable between different implementations of Gardens Point Component Pascal.*

If you want to create an exception object to abort program execution with a meaningful string, the library function **RTS.Throw(msg : ARRAY OF CHAR)** may be used. Exceptions thrown by this library function **can** be caught by a *RESCUE* clause.

## 6. Facilities of the CP Runtime System

### 6.1 Supplied libraries

This release has a small number of libraries supplied. These are –

- **Console**            this library writes strings and numbers to the console
- **Error**             this library writes strings and number to the error stream
- **ProgArgs**          this library provides access to the command line arguments, if any
- **GPFiles**            defines the supertype of *GPBinFiles.FILE* and *GPTextFiles.FILE*
- **GPText**            a basic library for handling text formatting
- **GPBinFiles**        reading and writing binary files
- **GPTextFiles**        reading and writing text files
- **RTS**                access to the facilities of the runtime system

For the most part these libraries are the ones that were required to bootstrap the compiler. More will come later ...

### 6.2 The runtime system RTS.cp

The runtime system provides a variety of low-level access facilities. The source file for this module, **RTS.cp**, is not really the source. This file is a dummy, as is denoted by the context-sensitive mark “*SYSTEM*” appearing before the keyword *MODULE*. All such “modules” are actually implemented various Java files *RTS.java*, *Console.java*, and so on. At runtime the corresponding classes are found as usual.

Here is the “source” of RTS.

```
(**  These are the user accessible static methods of the CP runtime system.
*    These are the environment-independent ones. Others are in CP*.cp
*    Note: the bodies of these procedures are dummies, this module is
*    compiled with -special. The real code is in RTS.java or other.
*)
```

```
SYSTEM MODULE RTS;
```

```
VAR defaultTarget- : ARRAY 4 OF CHAR;
```

```

TYPE
    CharOpen*      = POINTER TO ARRAY OF CHAR;

TYPE
    NativeType*    = POINTER TO RECORD END;
    NativeObject*  = POINTER TO RECORD END;
    NativeString*  = POINTER TO RECORD END;
    NativeException* = POINTER TO RECORD END;

PROCEDURE getStr(x : NativeException) : CharOpen;
    (** Get error message from Exception *)

PROCEDURE StrToReal*(IN s : ARRAY OF CHAR;
                     OUT r : REAL;
                     OUT ok : BOOLEAN);
    (** Parse array into an ieee double REAL *)

PROCEDURE StrToInt*(IN s : ARRAY OF CHAR;
                    OUT i : INTEGER;
                    OUT ok : BOOLEAN);
    (** Parse an array into a CP INTEGER *)

PROCEDURE StrToLong*(IN s : ARRAY OF CHAR;
                     OUT i : LONGINT;
                     OUT ok : BOOLEAN);
    (** Parse an array into a CP LONGINT *)

PROCEDURE RealToStr*(r : REAL;
                     OUT s : ARRAY OF CHAR);
    (** Decode a CP REAL into an array *)

PROCEDURE IntToStr*(i : INTEGER;
                     OUT s : ARRAY OF CHAR);
    (** Decode a CP INTEGER into an array *)

PROCEDURE LongToStr*(i : LONGINT;
                     OUT s : ARRAY OF CHAR);
    (** Decode a CP INTEGER into an array *)

PROCEDURE realToLongBits*(r : REAL) : LONGINT;
    (** Convert ieee double to longint with same bit pattern *)

PROCEDURE longBitsToReal*(l : LONGINT) : REAL;
    (** Convert ieee double to a longint with same bit pattern *)

PROCEDURE hiInt*(l : LONGINT) : INTEGER;
    (** Get hi-significant word of long integer *)

PROCEDURE loInt*(l : LONGINT) : INTEGER;
    (** Get lo-significant word of long integer *)

PROCEDURE Throw*(IN s : ARRAY OF CHAR);
    (** Abort execution with an error *)

```

```

PROCEDURE GetMillis*() : LONGINT;
(** Get time in milliseconds *)

PROCEDURE GetDateString*(OUT str : ARRAY OF CHAR);
(** Get a date string in some native format *)

PROCEDURE ClassMarker*(o : ANYPTR); (* write class name *)
END RTS.

```

The four character *defaultTarget* string will hold “*net*” when running on the .NET platform, and “*jvm*” when running under the Java Runtime Environment.

The word *SYSTEM* in the first line of the definition is a context sensitive mark, rather than a reserved word. This means that the word may be used as an identifier elsewhere in the program. This mark has special significance for the .NET platform. Users should not attempt to write their own *SYSTEM* modules.

## 7. Foreign Language Interface

### 7.1 Accessing the basic underlying types

The underlying types are accessible without any import other than RTS. At runtime the compiler queries the target flag, or takes the platform default value if there is no target command option.

If the target is “net” then *NativeObject*, *NativeString* and *NativeException* will be the CLS types **System.Object**, **System.String** and **System.Exception** respectively.

If the target is “jvm” then *NativeObject*, *NativeString* and *NativeException* will be the Java types **java.lang.Object**, **java.lang.String** and **java.lang.Exception** respectively.

In any case, literal strings may be implicitly coerced to either the native string type, or to the native object type. This saves a lot of clutter in code which interfaces to foreign libraries. However, if a CP-style, non-literal string, i.e. a nul-terminated array of *CHAR* needs to be transformed to a native string, the non-standard built-in function –

```

PROCEDURE MKSTR(IN s : ARRAY OF CHAR) : RTS.NativeString;

```

may be used.

### 7.2 Importing dummy definition modules

As an interim measure, the compiler has been enhanced so as to allow the construction of metainformation (.cps) files for foreign language libraries. Such modules must be compiled with the **-special** option. However, they are imported into ordinary modules in the same way as other modules.

Foreign language interfaces may be recognized by the context sensitive marks **FOREIGN** or **SYSTEM** preceding the keyword **MODULE** at the start of the file. Such “dummy” modules do not contain the code of the foreign language facilities, but simply define the interface to those facilities. The system marker has special meaning in the .NET platform, but has the same semantics as foreign in the JVM platform.

When a dummy definition module is compiled there are a small number of syntactic extensions and changes.



- Modules can be given an explicit external package name
- Procedures can be given an explicit external name
- Features with protected scope may be defined
- Static members of classes may be defined
- Escaped identifiers may be defined
- Interface types may be defined
- Overloaded names may be given aliases
- Constructors may be given an alias

The syntax - **FOREIGN MODULE Foo["ppre.psuf"]**; declares that this module will be found in package **ppre.psuf**. (Forward slash character "/" may be used instead of the dot here). It is not necessary to use this mechanism if the package has the default name as described in Section 3, subsection "*Fully Qualified Java Package Names*".

The syntax - **PROCEDURE (x : T)BarII\*["Bar"](i,j : INTEGER)**; declares that this procedure has the external name "Bar" and the internal (CP) name "BarII". This mechanism allows overloaded names in the Java runtime to be given non-overloaded aliases in CP.

The mark "!" is used to declare that a foreign name has protected scope.

If a name clashes with a CP keyword, it must be defined using the back-quote escape.

Here is an example of the syntax that is required to define a foreign interface type.

```
TYPE Foo* = POINTER TO INTERFACE RECORD END;
```

The keyword *INTERFACE* is reserved, and such a type cannot declare any fields in the record, nor can it define type-bound procedures that are not declared *ABSTRACT*.

Finally, constructors **must** be declared with the special name "<init>". Declaring a constructor is not necessary if only the no-arg constructor is required, since **NEW**(obj) works in this case as for other types in CP (see section 8.4 for more detail). If access to constructors with arguments is required, then these are given a CP alias, and are marked as constructors by using the magic explicit name. For the **target=net** version, the magic name is **".ctor"**.

### 7.3 Accessing Static Features of Foreign Classes

If a class has been imported from a foreign definition, and the class has static members, these may be accessed by means of a semantic extension to the designator grammar.

Normally, the syntactic construct –

```
QualifiedIdent {Selector}
```

is in error if the qualified identifier resolves to a type-identifier. However there are two exceptional cases where this is legal in *gpcp*. If a designator begins –

```
TypeIdentifier "." Identifier
```

where

- the type identifier resolves to an imported, foreign type, and
- the identifier is a static field or constant of the type, or
- the identifier is a static method of the type

then this is a legal reference to the static feature of the type.

In order to define such constructs in the syntax of dummy definitions the following syntax is added to the record syntax. Note that these extensions are only valid if the module is compiled with the **-special** command line option.

```
Record      → RECORD [ (“ TypeId “) ] { FieldList } [ STATIC { StatDecl } ] END.
StatDecl    → ProcHeading | StatConst | StatField .
StatConst   → identifier “=” ConstExpression .
StatField   → identifier “=” TypeId .
```

Procedure headings have the same syntax as elsewhere in the language.

## 8.0 Creating Foreign Definition Modules

This Section is only of relevance if you plan to write your own foreign definition modules. For most users the information in the previous section on the *usage* of these facilities will be sufficient.

### 8.1 Syntax of Foreign Definitions

The syntax of foreign definition is as follows. Unless otherwise defined here, the meanings of non-terminal symbols is the same as in the Component Pascal Report.

```
GPMModule    → Module | ForeignMod .
ForeignMod    → ( FOREIGN | SYSTEM ) MODULE ident [ string ] “;”
               ImportList DeclSeq END ident “.” .
DeclSeq       → { CONST { ConstDecl “;” } | TYPE { TypeDecl “:” } | VAR { VarDecl “;” } }
               { ProcHeading “;” | MethodHeading “;” }
ProcHeading   → PROCEDURE IdentDef [ “[“ string “]” ] [FormalPars] .
MethodHeading → PROCEDURE Receiver IdentDef [ “[“ string “]” ] [FormalPars]
               [ “,” NEW ] [ “,” ABSTRACT | EMPTY | EXTENSIBLE ] .
TypeDecl      → IdentDef “=” Type .
Type          → [ POINTER TO ] [Attributes] RECORD [ “[“ Qualident “]” ]
               FieldList { “;” FieldList }
               [ STATIC StaticDecl { “;” StaticDecl } ] END
               | Other types as in the Report .
StaticDecl    → IdentList “;” Type | IdentDef “=” ConstExpr | ProcHeading .
Attributes    → ABSTRACT | EXTENSIBLE | INTERFACE .
```

The syntax begins with the context sensitive mark “**FOREIGN**” or “**SYSTEM**”. On the *.NET* platform the system marker indicates that the code will be found in the runtime system assembly. In the *JVM*, where each class file contains a single class, the marker has the same semantic effect as “**FOREIGN**”.

### 8.2 Explicit package or namespace names

The way in which runtime names are generated from module names was described in Section 3.2. In the case of the *JVM* we have the following correspondence.

Component Pascal Name	JVM Name
<b>MODULE</b> ModNm;	CP.ModNm // <i>package name</i>
<b>TYPE</b> Cls = <b>RECORD</b> ... <b>END</b> ;	CP.ModNm.ModNm_Cls // <i>class name</i>
<b>VAR</b> varNm : Cls;	CP.ModNm.ModNm.varNm
<b>PROCEDURE</b> ProcNm();	CP.ModNm.ModNm.ProcNm()
<b>PROCEDURE</b> (t : Cls)MthNm();	CP.ModNm.ModNm_Cls.MthNm()
<b>END</b> ModNm.	

Notice that in the JVM there are no features that are defined outside of classes, so that the static entities *varNm* and *ProcNm* are considered at runtime to belong to an implicit static class with the same name as the module name. However, so far as an importing Component Pascal program is concerned, these features will be accessed by the familiar *ModuleName.memberName* syntax.

Component Pascal Name	.NET CLS Name
<b>MODULE</b> ModNm;	[ModNm]ModNm // <i>namespace</i>
<b>TYPE</b> Cls = <b>RECORD</b> ... <b>END</b> ;	[ModNm]ModNm.Cls // <i>class name</i>
<b>VAR</b> varNm : Cls;	[ModNm]ModNm.ModNm::varNm
<b>PROCEDURE</b> ProcNm();	[ModNm]ModNm.ModNm::ProcNm()
<b>PROCEDURE</b> (t : Cls)MthNm();	[ModNm]ModNm.Cls::MthNm()
<b>END</b> ModNm.	

In the virtual object system of *.NET* the situation is similar, with an implicit static class being defined with the same name as the module.

If, as a user, you are writing a foreign definition and plan to implement the library yourself in either Java or in C# (say), then you may define the foreign module in this way and write the foreign code so as to match the default “name mangling” scheme. In this case you may even use the same foreign definition for both versions of *gpcp*, and implement a foreign module on each underlying platform. If on the other hand you are planning to match a foreign definition to an existing library written in Java or C#, then you must override this default naming scheme.

The syntax “**FOREIGN MODULE** *ident* [*string*];” allows an arbitrary package or namespace name to be defined. For example, in order to access the facilities of the package **java.lang.Reflect** a foreign module might begin

```
FOREIGN MODULE java_lang_Reflect["java.lang.Reflect"];
```

Similarly, in order to access the facilities of the namespace **System.Reflect** in the assembly **mscorlib** a foreign module might begin

```
FOREIGN MODULE mscorlib_Reflect["[mscorlib]System.Reflect"];
```

Note that the form of the literal string is different on the two platforms, and thus any such foreign modules will be specific to a particular platform. Notice also that there is no mechanism to explicitly give a name to an implicit static class.

### 8.3 Dealing with overloaded names

Each of the underlying platforms allows name overloading for methods. This feature is deliberately not permitted in Component Pascal. Nevertheless, it is necessary to gain access to library methods that have overloaded names. The option of using explicit external method names facilitates this. Suppose we have two methods, both of which

are named *Add()*, one with a single integer parameter, and another with two. We might define these as follows in a foreign definition.

```
PROCEDURE (this : Cls)AddI*[ "Add" ](I : INTEGER) ,NEW;  
PROCEDURE (this : Cls)AddII*[ "Add" ](I,J : INTEGER) ,NEW;
```

Within the importing CP program the two names are distinct, but the program executable will correctly refer to the underlying overloaded methods. This name-mangling is rather awkward, particularly in the case of parameters of object types.

Since release (1.1) users are able to access the unmangled names of overloaded foreign methods directly. The N2CPS and J2CPS tools create symbol files that have overloaded names, and the compiler will match calls to the intended method. Because this is a language extension, the compiler is strict about matching calls to methods in the presence of automatic coercions. If more than one method matches, when taking into account all legal coercions, *gpcp* will reject the program and require the user to specify the intended coercions of the actual parameters.

#### 8.4 Interfacing to constructors

If a foreign class has a “no-arg” constructor, then this will be implicitly called whenever an object is created by the use of the standard procedure **NEW**. However if it is necessary to access constructors with arguments, then it is possible to define an alias for the constructor in a foreign module. In every case the constructor will be accessed by means of a static, value returning function that returns an object of the constructed class. The fact that this is a constructor must be made known to *gpcp* since the way in which these methods are called differs from other methods. On each underlying platform there is a “magic” name which is used for calling a constructor. On *JVM* the name is “<init>”, while on *.NET* the name is “**.ctor**”. These two strings are used as the explicit string which defines such a procedure in the foreign definition. An example of an interface to a constructor with arguments might be –

```
PROCEDURE Init*(width,height : INTEGER) : Rect,CONSTRUCTOR;
```

The identifier “**CONSTRUCTOR**” is not a reserved word, but a context sensitive mark that may be used as an ordinary identifier elsewhere in the program.

Note that this declaration would normally be declared in the static part of the record defining the class “Rect”. Calls to this procedure in a Component Pascal program, such as –

```
rec1 := F.Rect.NewRectangle(25,17);
```

would translate into a call to the appropriate one of –

```
namespaceName.Rect::.ctor(int32,int32)  
packageName.Rect.<init>(II)
```

Of course, if you extend a foreign class that does not have a public no-arg constructor, then you will not be able to construct values of your own type using **NEW**, since this implicitly calls the no-arg constructor of its super type. In this case, it is necessary to define a new constructor signature for your extended type. In release 1.2 there are two ways to do this. If the desired constructor has the same signature as the constructor of

the supertype, then the first method may be used. In the case of the example above, the required syntax is shown in the following fragment –

```
TYPE MyRect* = POINTER TO RECORD (A.Rect) ... END;  
...  
PROCEDURE Init*(w,h : INTEGER): MyRect, CONSTRUCTOR;
```

The constructor does not have a body, and simply passes its arguments to the super-type constructor with matching signature.

The new syntax in version 1.2 is considerably more flexible. The Component Pascal constructor does not require to have the same signature as the constructor of the super-type. An example of the syntax is –

```
PROCEDURE MkMyRect* (formals) : MyRect, BASE (actuals) ;  
    Local-declarations  
BEGIN  
    Constructor body  
    RETURN SELF ;  
END MkMyRect ;
```

The identifier “BASE” is not a reserved word, but is a context sensitive mark. It denotes the super-type constructor with the signature matching the types of the actual parameter expressions. This super-type constructor will be called as the first action of the constructor, before the new fields of the derived object are initialized. Within the body of the constructor the object under construction is denoted by the identifier “SELF”. The constructor must return this object along every terminating path of the body. It is an error if the actual parameter expression types in the super-call do not choose a unique super-type constructor.

### 8.5 Declaring static features of classes

Classes in foreign modules may be declared either as records or as pointers to records. However, it is recommended that on the *JVM* platform the pointer form be always used, as a helpful reminder to the user that at runtime the objects will be dynamically allocated. On the *.NET* platform value classes should be declared as plain records, with no explicit base type. On both platforms array types should be declared as pointers to arrays, again reminding the user that all arrays are dynamically (and explicitly) allocated.

In order to access static features of foreign classes, the syntax extension of records given in Section 8.1 must be used. In the optional static section of a record declaration we may define constants, static fields and static (i.e. non type-bound) procedures.

We may consider the following example –

<i>Component Pascal Foreign Definition</i>	<i>Component Pascal Usage</i>
<b>FOREIGN MODULE</b> ModNm;	
<b>TYPE</b> Cls =	ModNm.Cls <i>// class name</i>
<b>POINTER TO RECORD</b>	
<b>STATIC</b>	
statVar* : <b>CHAR</b> ;	ModNm.Cls.statVar
<b>PROCEDURE</b> StatProc();	ModNm.Cls.StatProc()
<b>END</b> ;	
<b>END</b> ModNm.	

In this example we select the static member by qualifying the designator by the type-name of the class.

Type-bound methods will be defined lexically outside of the record declaration in the normal CP way, remembering that only the heading is required. On the *.NET* platform the distinction between virtual and instance methods is made automatically. Instance methods are *NEW* but not *EXTENSIBLE*. On the *JVM* platform the possibility of optimizing the calls to such methods are left to the JIT to determine.



*Note that the foreign modules which arise from C# on the .NET platform or are written in Java can never have static features outside of classes. If you are writing the foreign module yourself you may use the default class naming scheme described in Section 3. However if you are matching an existing package, you will need to use the explicit name override described earlier in this Section. This allows you to control the package name, but does not allow you to name an implicit static class for static features. Therefore you will need to use the mechanisms of this sub-section if the package contains any static features.*

## 9. Installing and Trying the Compiler

### 9.1 Installation

If you are installing on the Microsoft Windows platform, then the simplest scheme is to use the installer version. In this case you should not need to do anything other than make responses to the installer's queries.

The compiler also comes packaged in a single zip file that is usually unzipped into a directory with a name such as **gpcp**. There are seven sub-directories. These are –

- **bin** the binary files of the compiler
- **CP** the root of the jvm class tree
- **docs** the documentation, including this file
- **examples** some example programs
- **libs** contains the simple library files
- **source** the source files (will have compiler source later)
- **work** a working directory to play around with

The bin directory needs to be on your PATH, and the environment variable CPSYM must point to the libs directory. The **gpcp** directory must be on the classpath passed to the **java** command. On Unix, the variables might be –

```
CPSYM=.:$CPROOT/libs
PATH=$PATH:$CPROOT/bin
```

and the compiler will be run starting with the command

```
java -DCPSYM=$CPSYM -classpath .:$CPROOT CP.gpcp.gpcp \
    other-options filenames
```

Alternatively, a shell script or function to construct the command makes good sense. The supplied scripts **cprun** and **cpint** are simple examples of this.

On Windows systems, the variables might be set as follows

```
set CPSYM=.;C:\gpcp\libs
set PATH=%PATH%;C:\gpcp\bin
```

and the compiler will be run starting with the command

```
java -DCPSYM=%CPSYM% -classpath .;C:\gpcp CP.gpcp.gpcp \
    other-options filenames
```

The supplied scripts **cprun.bat** and **cpint.bat**, found in the **\gpcp\bin** directory may help here.

## 10. Future Releases

Release 1.1 still has a very limited range of libraries packaged with it, essentially only those needed to bootstrap the compiler. The distribution is sufficient to try out the compiler, and is being updated on a frequent basis. We expect new releases to contain new tools and new libraries.

Updates are announced and available from [www.plasrc.qut.edu.au/ComponentPascal](http://www.plasrc.qut.edu.au/ComponentPascal)

### Changes from 1.1.6

The following changes and corrections are included in the 1.2.0 release.

1. The semantics of “super-calls” were incorrect in the case that the immediate super-type did not define the method being overridden. In version 1.2 the notation “**Foo^ ( )**” denotes the overridden method no matter how distant it is in the inheritance hierarchy.
2. New options have been implemented for output directories.
3. On the .NET platform the default behavior for the **/nodebug** option is to use the direct PE-file writer. This is significantly faster than going through ilasm. Unfortunately, this new file-writer does not produce debug symbols at this stage. There is separate documentation for the PEAPI component included with this release.
4. The permitted semantics for constructors with arguments is significantly enhanced. This is of some importance when deriving from types that do not have public no-arg constructors.

### Changes from 1.1.4

The following changes and corrections are included in the 1.1.6 release –

1. Uplevel addressing of reference parameters is now permitted in the .NET release, although this has inexact semantics in some cases.
2. A number of corrections to the JVM code-emitter have been added.
3. The new builtin function **BOX** has been added.
4. Trapping of types that attempt to indirectly include themselves is improved.
5. An automatic renaming scheme is implemented for modules that attempt to export types with the same name as the module on the .NET platform.

### Changes from 1.1.3

The following changes and corrections are included in this release –

1. The copyright notice has been revised. GPCP is still open source, but now has a “*FreeBSD*-like” licence agreement.
2. A correction to the Java class-file emitter now puts correct visibility markers on package-public members. *Appletviewer* didn’t care, but browsers objected!
3. It is now permitted to export type-bound procedures of non-exported types, provided the procedure overrides an exported method of a super-type.
4. More line-markers are emitted to IL. This makes it possible to place a breakpoint on the predicate of a conditional statement, and have the debugger stop on the predicate rather than the next executable statement.
5. The type-resolution code of *SymFileRW.cp* has been radically revised. It is believed that the code is now immune to certain problems caused by importing foreign libraries with circular dependencies.