

COMPILER DESIGN

ASSIGNMENT-1

(COMPILATION PIPELINE AND
ITS DIFFERENT COMPONENTS)

SUBMITTED BY:

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Part 1.

Source file : test.c

```
1 #include<stdio.h>
2 #define SUCCESS 0
3
4 int main(int argc, char **argv){
5     int c;
6     printf("\n HEllO World %d %d\n", c, argc);
7     return (SUCCESS);
8 }
```

Command: gcc -Wall --verbose --save-temps -o first-exec test.c

```
gcc -Wall -v -verbose --save-temps -o first-exec test.c
Using built-in specs.
COLLECT_GCC=gcc
COLLECT_LTO_WRAPPER=/usr/lib/gcc/x86_64-linux-gnu/11/lto-wrapper
OFFLOAD_TARGET_NAMES=nvptx-none:amdgc-nv-amdhsa
OFFLOAD_TARGET_DEFAULT=1
Target: x86_64-linux-gnu
Configured with: ../src/configure -v --with-pkgversion='Ubuntu 11.3.0-1ubuntu1-22.04.1' --with-bugurl=file:///usr/share/doc/gcc-11/README.Bugs --enable-languages=c,ada,c++,go,brig,d,fortran,objc,obj-c++,m2 --prefix=/usr --with-gcc-major-version-only --program-suffix=-11 --program-prefix=x86_64-linux-gnu- --enable-shared --enable-linker-build-id --libexecdir=/usr/lib --without-included-gettext --enable-threads=posix --libdir=/usr/lib --enable-nls --enable-bootstrap --enable-clocale=gnu --enable-libstdcxx-debug --enable-libstdcxx-time=yes --with-default-libstdcxx-abi=new --enable-gnu-unique-object --disable-vtable-verify --enable-plugin --enable-default-pie --with-system-zlib --enable-libphobos-checking-release --with-target-system-zlib=auto --enable-objc-gc=auto --enable-multitarch --disable-werror --enable-cet --with-arch=32=i686 --with-abi=m64 --with-multilib-list=m32,m64,mx32 --enable-multilib --with-tune=generic --enable-offload-targets=nvptx-none=/build/gcc-11-ayXV0E/gcc-11-11.3.0/debian/tmp-nvptx/usr,amdgc-nv-amdhsa=/build/gcc-11-ayXV0E/gcc-11-11.3.0/debian/tmp-gcn/usr --without-cuda-driver --enable-checking=release --build=x86_64-linux-gnu --host=x86_64-linux-gnu --target=x86_64-linux-gnu --with-build-config=bootstrap-lto-lean --enable-link-serialization=2
Thread model: posix
Supported LTO compression algorithms: zlib zstd
gcc version 11.3.0 (Ubuntu 11.3.0-1ubuntu1-22.04.1)
COLLECT_GCC_OPTIONS='-Wall' '-v' '-save-temps' '-o' 'first-exec' '-mtune=generic' '-march=x86-64' '-dumpdir' 'first-exec-'
/usr/lib/gcc/x86_64-linux-gnu/11/cc1 -E -quiet -v -multitarch x86_64-linux-gnu test.c -mtune=generic -march=x86-64 -Wall -fpreprocess -fasynchronous-unwind-tables -fstack-protector-strong -Wformat-security -fstack-clash-protection -fcf-protection -o first-exec-test.i
ignoring nonexistent directory "/usr/local/include/x86_64-linux-gnu"
ignoring nonexistent directory "/usr/lib/gcc/x86_64-linux-gnu/11/include-fixed"
ignoring nonexistent directory "/usr/lib/gcc/x86_64-linux-gnu/11/../../../../x86_64-linux-gnu/include"
#include "..." search starts here:
#include <...> search starts here:
/usr/lib/gcc/x86_64-linux-gnu/11/include
/usr/local/include
/usr/include/x86_64-linux-gnu
/usr/include
End of search list.
COLLECT_GCC_OPTIONS='-Wall' '-v' '-save-temps' '-o' 'first-exec' '-mtune=generic' '-march=x86-64' '-dumpdir' 'first-exec-'
/usr/lib/gcc/x86_64-linux-gnu/11/cc1 -fpreprocessed first-exec-test.i -quiet -dumpdir first-exec- -dumpbase test.c -dumpbase-ext .c -mtune=generic -march=x86-64 -Wall -version -fasynchronous-unwind-tables -fstack-protector-strong -Wformat-security -fstack-clash-protection -fcf-protection -o first-exec-test.o
GNU C17 (Ubuntu 11.3.0-1ubuntu1-22.04.1) version 11.3.0 (x86_64-linux-gnu)
compiled by GNU C version 11.3.0, GMP version 6.2.1, MPFR version 4.1.0, MPC version 1.2.1, isl version isl-0.24-GMP

GCC heuristics: --param gcc-min-expand=100 --param gcc-min-heapsize=131072
GNU C17 (Ubuntu 11.3.0-1ubuntu1-22.04.1) version 11.3.0 (x86_64-linux-gnu)
```

```
GNU C17 (Ubuntu 11.3.0-1ubuntu1-22.04) version 11.3.0 (x86_64-linux-gnu)
  compiled by GNU C version 11.3.0, GMP version 6.2.1, MPFR version 4.1.0, MPC version 1.2.1, isl version isl-0.24-GMP

GCC heuristics: --param gcc-min-expand=100 --param gcc-min-heapsize=131072
Compiler executable checksum: e13e2dc98bfa73227c4000e476a9388
test.c: In function 'main':
test.c:6:5: warning: 'c' is used uninitialized [-Wuninitialized]
     6 |     printf("\n Hello World %d %d\n", c, argc);
       |     ~~~~~^~~~~~
COLLECT_GCC_OPTIONS='-Wall' '-v' '-save-temps' '-o' 'first-exec' '-mtune=generic' '-march=x86-64' '-dumpdir' 'first-exec'
as -v -64 -o first-exec-test.o first-exec-test.s
GNU assembler version 2.38 (x86_64-linux-gnu) using BFD version (GNU Binutils for Ubuntu) 2.38
COMPILER_PATH=/usr/lib/gcc/x86_64-linux-gnu/11:/usr/lib/gcc/x86_64-linux-gnu/11:/usr/lib/gcc/x86_64-linux-gnu/11:/usr/lib/gcc/x86_64-linux-gnu/11:/u
sr/lib/gcc/x86_64-linux-gnu/
LIBRARY_PATH=/usr/lib/gcc/x86_64-linux-gnu/11:/usr/lib/gcc/x86_64-linux-gnu/11/../../../../x86_64-linux-gnu:/usr/lib/gcc/x86_64-linux-gnu/11/../../../../
../lib/x86_64-linux-gnu:/lib/../../../../lib/x86_64-linux-gnu:/usr/lib/../../../../lib/x86_64-linux-gnu/11/../../../../lib/x86_64-linux-gnu/11/../../../../lib/x86_64-l
inux-gnu/11/../../../../lib/x86_64-linux-gnu/11/../../../../lib/x86_64-linux-gnu/11/../../../../lib/x86_64-linux-gnu/11/../../../../lib/x86_64-linux
COLLECT_GCC_OPTIONS='-Wall' '-v' '-save-temps' '-o' 'first-exec' '-mtune=generic' '-march=x86-64' '-dumpdir' 'first-exec'
/usr/lib/gcc/x86_64-linux-gnu/11/collect2 -plugin /usr/lib/gcc/x86_64-linux-gnu/11/liblto_plugin.so -plugin-opt=/usr/lib/gcc/x86_64-linux-gnu/11/to
-wrapper -plugin-opt=-fresolution=first-exec.res -plugin-opt=-pass-through=lgcc -plugin-opt=-pass-through=lgcc_s -plugin-opt=-pass-through=lc -plu
gin-opt=-pass-through=lgcc -plugin-opt=-pass-through=lgcc_s -build-id -eh-frame-hdr -m elf_x86_64 --hash-style=gnu --as-needed -dynamic-linker /l
ib64/ld-linux-x86-64.so.2 -pie -z now -z relro -o first-exec /usr/lib/gcc/x86_64-linux-gnu/11/../../../../x86_64-linux-gnu/Scrt1.o /usr/lib/gcc/x86_64-l
inux-gnu/11/../../../../x86_64-linux-gnu/crti.o /usr/lib/gcc/x86_64-linux-gnu/11/crtbeginS.o -L/usr/lib/gcc/x86_64-linux-gnu/11 -L/usr/lib/gcc/x86_64-l
inux-gnu/11/../../../../x86_64-linux-gnu -L/usr/lib/gcc/x86_64-linux-gnu/11/../../../../lib -L/lib/x86_64-linux-gnu -L/lib/../../../../lib -L/usr/lib/x86_64-lin
ux-gnu -L/usr/lib/../../../../lib -L/usr/lib/gcc/x86_64-linux-gnu/11/../../../../first-exec-test.o -lgcc -push-state --as-needed -lgcc_s --pop-state -lc -lgcc -p
ush-state --as-needed -lgcc_s --pop-state /usr/lib/gcc/x86_64-linux-gnu/11/crtendS.o /usr/lib/gcc/x86_64-linux-gnu/11/../../../../x86_64-linux-gnu/crti.
o
COLLECT_GCC_OPTIONS='-Wall' '-v' '-save-temps' '-o' 'first-exec' '-mtune=generic' '-march=x86-64' '-dumpdir' 'first-exec'
```

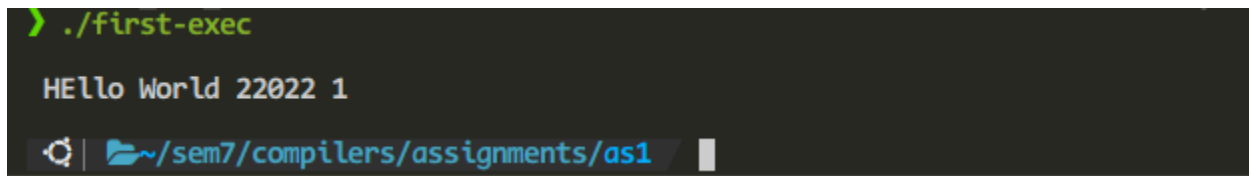
Compiler Flags:

1. **-Wall** : Enables all compiler's warning messages like unused variables warning messages, etc
2. **-verbose** : produce detailed output for diagnostic purposes thus makes a program easier to debug.
3. **-save-temps** : Store the usual “temporary” intermediate files permanently.
4. **-o first-exec** : writes the build output to file “first-exec”

Files :



1. **test.c** : source code file
2. **first-exec-test.i** : expanded source code (produced by preprocessor)
3. **first-exec-test.s** : assembly code (produced by compiler)
4. **first-exec-test.o** : relocatable object code (produced by assembler)
5. **first-exec** : executable output file (produced by linker)
6. The loader then finally executes the output file.



first-exec-test.i

```
first-exec-test.i x
1 # 0 "test.c"
2 # 0 "<built-in>"
3 # 0 "<command-line>"
4 # 1 "/usr/include/stdc-predef.h" 1 3 4
5 # 0 "<command-line>" 2
6 # 1 "test.c"
7 # 1 "/usr/include/stdio.h" 1 3 4
8 # 27 "/usr/include/stdio.h" 3 4
9 # 1 "/usr/include/x86_64-linux-gnu/bits/libc-header-start.h" 1 3 4
```

first-exec-test.s

```
first-exec-test.s x
1 .file "test.c"
2 .text
3 .section .rodata
4 .LC0:
5 .string "\n Hello World %d %d\n"
6 .text
7 .globl main
8 .type main, @function
9 main:
```

first-exec-test.o

```
first-exec-test.o x
1 ELF > @
2 UH H } H u U E H H N
3 Hello World %d %d
4 GCC: (Ubuntu 11.3.0-1ubuntu1~22.04.1) 11.3.
0 GNU zR x
6 E C
5 m
6 test.c main printf
+ .symtab .strtab .shs
```

first-exec

```
first-exec x
1 ELF > @ 6 @ 8
2 @ @ @ @ @
3 Hello World %d %d
4 ; 0 d $ 4 D L -
5 m
```

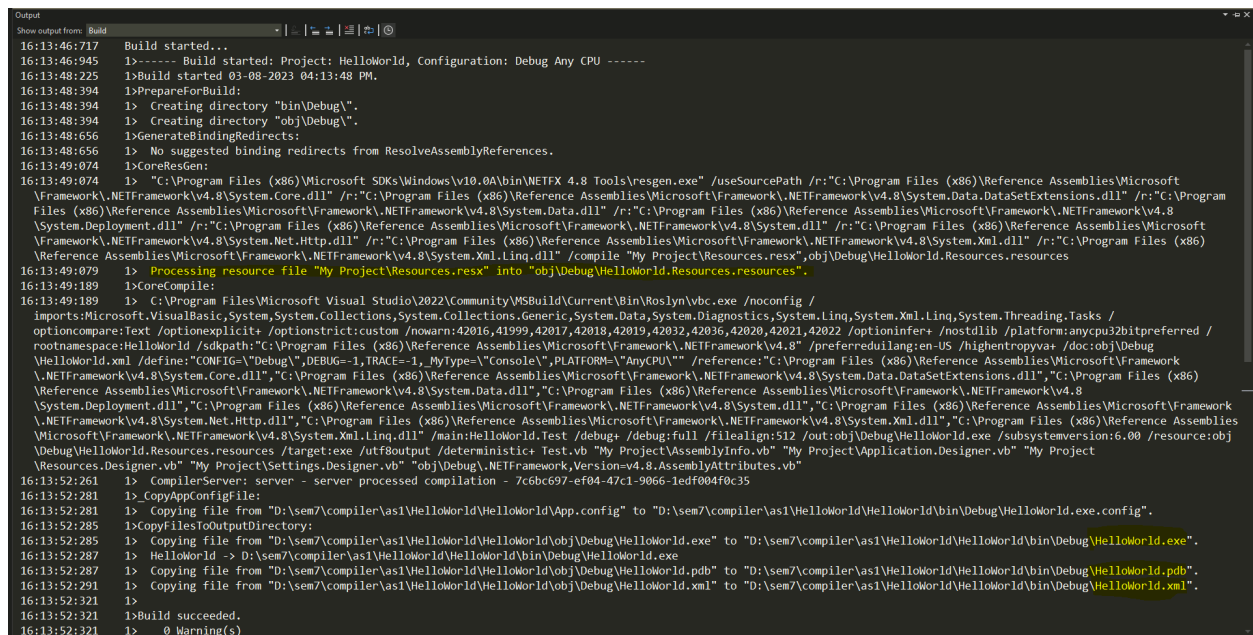
Part 2.

Source File : test.vb



```
1 0 references
2  Module Test
3      0 references
4      Sub Main()
5          Console.WriteLine("Hello World")
6          Console.ReadKey()
7      End Sub
8 End Module
```

Build Output :



```
16:13:46:717 Build started...
16:13:46:945 1>----- Build started: Project: HelloWorld, Configuration: Debug Any CPU -----
16:13:48:225 1>Build started 03-08-2023 04:13:48 PM.
16:13:48:394 1>PrepareForBuild:
16:13:48:394 1> Creating directory "bin\Debug\".
16:13:48:394 1> Creating directory "obj\Debug\".
16:13:48:656 1>GenerateBindingRedirects:
16:13:48:656 1> No suggested binding redirects from ResolveAssemblyReferences.
16:13:49:074 1>CoreResGen:
16:13:49:074 1> "C:\Program Files (x86)\Microsoft SDKs\Windows\v10.0A\bin\NETFX 4.8 Tools\resgen.exe" /useSourcePath /r:"C:\Program Files (x86)\Reference Assemblies\Microsoft\
Framework\NETFramework\v4.8\System.Core.dll" /r:"C:\Program Files (x86)\Reference Assemblies\Microsoft\Framework\NETFramework\v4.8\System.Data.DataSetExtensions.dll" /r:"C:\Program
Files (x86)\Reference Assemblies\Microsoft\Framework\NETFramework\v4.8\System.Data.dll" /r:"C:\Program Files (x86)\Reference Assemblies\Microsoft\Framework\NETFramework\v4.8
\System.Deployment.dll" /r:"C:\Program Files (x86)\Reference Assemblies\Microsoft\Framework\NETFramework\v4.8\System.dll" /r:"C:\Program Files (x86)\Reference Assemblies\Microsoft
\Framework\NETFramework\v4.8\System.Net.Http.dll" /r:"C:\Program Files (x86)\Reference Assemblies\Microsoft\Framework\NETFramework\v4.8\System.Xml.dll" /r:"C:\Program Files (x86)
\Reference Assemblies\Microsoft\Framework\NETFramework\v4.8\System.Xml.Linq.dll" /compile "My Project\Resources.resx" /obj:obj\Debug\HelloWorld.Resources.resources
16:13:49:079 1> Processing resource file "My Project\Resources.resx" into "obj\Debug\HelloWorld.Resources.resources".
16:13:49:189 1>CoreCompile:
16:13:49:189 1> C:\Program Files\Microsoft Visual Studio\2022\Community\MSBuild\Current\Bin\Roslyn\vbcc.exe /noconfig /
Imports:Microsoft.VisualBasic,System,System.Collections.Generic,System.Data,System.Diagnostics,System.Linq,System.Xml.Linq,System.Threading.Tasks /
optioncompare:Text /optionexplicit:/optionstrict:custom /nowarn:42016,41999,42017,42018,42019,42032,42036,42020,42021,42022 /optioninfer+/nostdlib /platform:anycpu32bitpreferred /
rootnamespace:HelloWorld /sdkpath:"C:\Program Files (x86)\Reference Assemblies\Microsoft\Framework\NETFramework\v4.8" /preferredullang=en-US /highentropyv++ /doc:obj\Debug
\HelloWorld.xml /define:"CONFIG=Debug,DEBUG=1,TRACE=1,MyType=Console,PLATFORM=AnyCPU" /reference:"C:\Program Files (x86)\Reference Assemblies\Microsoft\Framework
\NETFramework\v4.8\System.Core.dll","C:\Program Files (x86)\Reference Assemblies\Microsoft\Framework\NETFramework\v4.8\System.Data.DataSetExtensions.dll","C:\Program Files (x86)
\Reference Assemblies\Microsoft\Framework\NETFramework\v4.8\System.Data.dll","C:\Program Files (x86)\Reference Assemblies\Microsoft\Framework\NETFramework\v4.8
\System.Deployment.dll","C:\Program Files (x86)\Reference Assemblies\Microsoft\Framework\NETFramework\v4.8\System.dll","C:\Program Files (x86)\Reference Assemblies\Microsoft\Framework
\NETFramework\v4.8\System.Net.Http.dll","C:\Program Files (x86)\Reference Assemblies\Microsoft\Framework\NETFramework\v4.8\System.Xml.dll","C:\Program Files (x86)\Reference Assemblies
\Microsoft\Framework\NETFramework\v4.8\System.Xml.Linq.dll" /main:HelloWorld.Test /debug+ /debug:full /filealign:512 /out:obj\Debug\HelloWorld.exe /subsystemversion:6.00 /resource:obj
\Debug\HelloWorld.Resources.resources /target:exe /utf8out /deterministic Test.vb "My Project\AssemblyInfo.vb" "My Project\Application.Designer.vb" "My Project
\Resources.Designer.vb" "My Project\Settings.Designer.vb" "obj\Debug\NETFramework,Version=v4.8.AssemblyAttributes.vb"
16:13:52:261 1> CompilerServer: server - server processed compilation - 7c6bc697-ef04-47c1-9066-1edf004f0c35
16:13:52:281 1> CopyAppConfigFile:
16:13:52:281 1> Copying file from "D:\sem7\compiler\as1\HelloWorld\HelloWorld\App.config" to "D:\sem7\compiler\as1\HelloWorld\HelloWorld\bin\Debug\HelloWorld.exe.config".
16:13:52:285 1>CopyFilesToOutputDirectory:
16:13:52:285 1> Copying file from "D:\sem7\compiler\as1\HelloWorld\HelloWorld\obj\Debug\HelloWorld.exe" to "D:\sem7\compiler\as1\HelloWorld\HelloWorld\bin\Debug\HelloWorld.exe".
16:13:52:287 1> HelloWorld -> D:\sem7\compiler\as1\HelloWorld\HelloWorld\bin\Debug\HelloWorld.exe
16:13:52:287 1> Copying file from "D:\sem7\compiler\as1\HelloWorld\HelloWorld\obj\Debug\HelloWorld.pdb" to "D:\sem7\compiler\as1\HelloWorld\HelloWorld\bin\Debug\HelloWorld.pdb".
16:13:52:291 1> Copying file from "D:\sem7\compiler\as1\HelloWorld\HelloWorld\obj\Debug\HelloWorld.xml" to "D:\sem7\compiler\as1\HelloWorld\HelloWorld\bin\Debug\HelloWorld.xml".
16:13:52:321 1>Build succeeded.
16:13:52:321 1> 0 Warning(s)
```

On compilation of Visual Basic Project in Visual Studio, several intermediate files are generated during the compilation process which are temporary and are typically stored in temporary directories “**bin** or **obj**” (object) folders within the project's directory. These files include compiled code, references to other assemblies, and metadata.

1. **Resource Files:** Intermediate resource files are generated to hold these resources in a format that can be embedded in the final assembly. They have the **.resources** extension.
2. **Metadata Files:** These files contain information about the types, methods, properties, and other metadata in the code. They have the **.xml** extension.
3. **Debugging Symbols:** Debug symbols, often referred to as **PDB** (Program Database) files, are generated to aid in debugging. They contain information about the mapping between the source code and the compiled code, which allows us to step through and debug code effectively. They have the **.pdb** extension.

4. **Temporary Compiled Assemblies:** Finally Temporary compiled assemblies are created during the compilation process. They have the **.exe** or **.dll** extension.

Files Produced :

```
Windows PowerShell
PS D:\sem7\compiler\as1> tree /f
Folder PATH listing for volume New Volume
Volume serial number is 7246-4F06
D:..
├── HelloWorld
│   └── HelloWorld.sln
├── HelloWorld
│   ├── App.config
│   ├── HelloWorld.vbproj
│   ├── HelloWorld.vbproj.user
│   ├── Test.vb
│   ├── bin
│   │   └── Debug
│   │       ├── HelloWorld.exe
│   │       ├── HelloWorld.exe.config
│   │       ├── HelloWorld.pdb
│   │       └── HelloWorld.xml
│   ├── My Project
│   │   ├── Application.Designer.vb
│   │   ├── Application.myapp
│   │   ├── AssemblyInfo.vb
│   │   ├── Resources.Designer.vb
│   │   ├── Resources.resx
│   │   ├── Settings.Designer.vb
│   │   └── Settings.settings
│   └── obj
│       └── Debug
│           ├── .NETFramework,Version=v4.8.AssemblyAttributes.vb
│           ├── HelloWorld.exe
│           ├── HelloWorld.pdb
│           ├── HelloWorld.Resources.resources
│           ├── HelloWorld.vbproj.AssemblyReference.cache
│           ├── HelloWorld.vbproj.CoreCompileInputs.cache
│           ├── HelloWorld.vbproj.FileListAbsolute.txt
│           ├── HelloWorld.vbproj.GenerateResource.cache
│           ├── HelloWorld.vbproj.SuggestedBindingRedirects.cache
│           └── HelloWorld.xml
PS D:\sem7\compiler\as1> █
```

The additional files and folders are due to creation of a project *HelloWorld.sln* in Visual Studio which is necessary to run a program.

HelloWorld.Resources.resources

```
1  System.Resources.ResourceReader, mscorlib, Version=4.0.0.0, Culture=neutral,
   PublicKeyToken=b77a5c561934e089#System.Resources.RuntimeResourceSet
```

HelloWorld.pdb

```
1 Microsoft C/C++ MSF 7.00
2 %DS%K%<%J%
3 %c%: %-%{ %u%, %
4 %Ur%
5 %c%: %-%{ %u%, %
6 %Ur%
7 %j4L8%_n)% %
8
9 %GetType%. %? %YY%I% %M%D%2%*%
10 %K%(
11 %<%0% %
12 %
13 %?%*%
14 %<%0% %
15 %H%,
```

HelloWorld.xml

```
1  <?xml version="1.0"?>
2  <doc>
3  <assembly>
4  <name>
5  HelloWorld
6  </name>
7  </assembly>
8  <members>
9  <member name="T:HelloWorld.My.Resources.Resources">
10 <summary>
11 |   A strongly-typed resource class, for looking up localized strings, etc.
12 </summary>
13 </member>
14 <member name="P:HelloWorld.My.Resources.Resources.ResourceManager">
15 <summary>
16 |   Returns the cached ResourceManager instance used by this class.
17 </summary>
18 </member>
19 <member name="P:HelloWorld.My.Resources.Resources.Culture">
20 <summary>
21 |   Overrides the current thread's CurrentUICulture property for all
22 |   resource lookups using this strongly typed resource class.
23 </summary>
24 </member>
25 </members>
26 </doc>
```