PE102

ortable xecutable

a Windows executable format overview

MZ DOS HEADER
PE HEADER
NT HEADERS
FILE HEADER
OPTIONAL HEADER
DATA DIRECTORY
EXPORT, IMPORT, ADDRESS TABLE
RESOURCES, EXCEPTIONS, RELOCATIONS
DEBUG, TLS, SAFESEH, .NET
SECTIONS

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HEADERS & SECTIONS

Relative Virtual Address
Virtual Address (requires relocation)
offset
relative offset

Constants

File header

IMAGE_FILE_MACHINE_*	Machine
I386	014c
ARMV7	01c4
AMD64	8664

IMAGE_FILE_*	Characteristics
RELOCS_STRIPPED	0001
EXECUTABLE_IMAGE	0002
LINE_NUMS_STRIPPED	0004
LOCAL_SYMS_STRIPPED	0008
LARGE_ADDRESS_AWARE	0020
32BIT_MACHINE	0100
DEBUG_STRIPPED	0200
DLL	2000

Optional Header

IMAGE_NT_OPTIONAL_HDR*_MAGIC	Magic
32	010b
64	020b

IMAGE_SUBSYSTEM_*	Subsystem
NATIVE (driver)	0001
WINDOWS_GUI	0002
WINDOWS_CUI (console)	0003

IMAGE_DLLCHARACTERISTICS_*	DllCharacteristics
DYNAMIC_BASE (aslr)	0040
NX_COMPAT (dep)	0100
NO_SEH	0400
TERMINAL_SERVER_AWARE	8000

Section

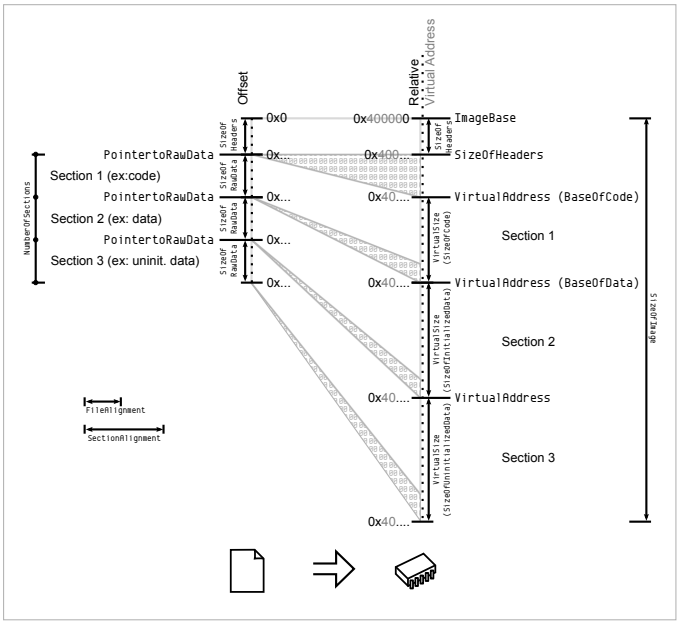
IMAGE_SCN_*	Characteristics
CNT_*	
CODE	00000020
INITIALIZED_DATA	00000040
UNINITIALIZED_DATA	00000080
MEM_*	
DISCARDABLE	02000000
SHARED (risky!)	10000000
EXECUTE	20000000
READ	40000000
WRITE	80000000

Relocations

IMAGE_REL_BASED_*	TypeOffset
ABSOLUTE	0
HIGHLOW	3

Resources

RT_*	NameID
BITMAP	02
ICON	03
MENU	04
DIALOG	05
STRING	06
GROUP_ICON	0d
VERSION	10
MANIFEST	18



OFFSET 0 — DOS Header

IMAGE_DOS_HEADER

00+2 e_magic MZ
02+2 e_cblp
04+2 e_cp exe size
06+2 e_crlc
08+2 e_cparhdr exe start
0a+2 e_minalloc
0c+2 e_maxalloc
0e+2 e_ss initial ss
10+2 e_sp initial sp
12+2 e_csum
14+2 e_ip
16+2 e_cs
18+2 e_lfarlc
1a+2 e_ovno
1c+2 e_res[4]
24+2 e_oemid
26+2 e_oeminfo
28+2 e_res2[10]
3c+4 e_lfanew

PE Header

IMAGE_NT_HEADERS(32/64)

00+04 Signature PE\0\0
04+14 FileHeader

IMAGE_FILE_HEADER

00+2 Machine CPU architecture
02+2 NumberOfSections
04+4 TimeDateStamp
08+4 PointerToSymbolTable
0c+4 NumberOfSymbols
10+2 SizeOfOptionalHeader
12+2 Characteristics exe/dll,relocs

18+60/+70 OptionalHeader

IMAGE_OPTIONAL_HEADER(32/64)

64b 32b
00+2 00+2 Magic 32b or 64b
02+1 02+1 MajorLinkerVersion required with signatures
03+1 03+1 MinorLinkerVersion
04+4 04+4 SizeOfCode
08+4 08+4 SizeOfInitializedData
0c+4 0c+4 SizeOfUninitializedData
10+4 10+4 AddressOfEntryPoint → where execution starts
14+4 14+4 BaseOfCode
---- 18+4 BaseOfData
18+8 1c+4 ImageBase suggested address to load the file
20+4 20+4 SectionAlignment -2^y, with y≥x
24+4 24+4 FileAlignment -2^x
28+2 28+2 MajorOperatingSystemVersion
2a+2 2a+2 MinorOperatingSystemVersion
2c+2 2c+2 MajorImageVersion
2e+2 2e+2 MinorImageVersion
30+2 30+2 MajorSubsystemVersion 4:4W95 5:2k2000 6:2Vista
32+2 32+2 MinorSubsystemVersion
34+4 34+4 Win32VersionValue overrides OS values in Thread Environment Block
38+4 38+4 SizeOfImage
3c+4 3c+4 SizeOfHeaders not always sizeof(Headers)
40+4 40+4 CheckSum only used for drivers
44+2 44+2 Subsystem executable/driver...
46+2 46+2 DllCharacteristics
48+8 48+4 SizeOfStackReserve
50+8 4c+4 SizeOfStackCommit
58+8 50+4 SizeOfHeapReserve
60+8 54+4 SizeOfHeapCommit
68+4 58+4 LoaderFlags
6c+4 5c+4 NumberOfRvaAndSizes ≤16
70+8 60+8 VirtualAddress, Size

SizeofOptionalHeader

Data Directories

IMAGE_DATA_DIRECTORY[]

NumberOfRvaAndSizes

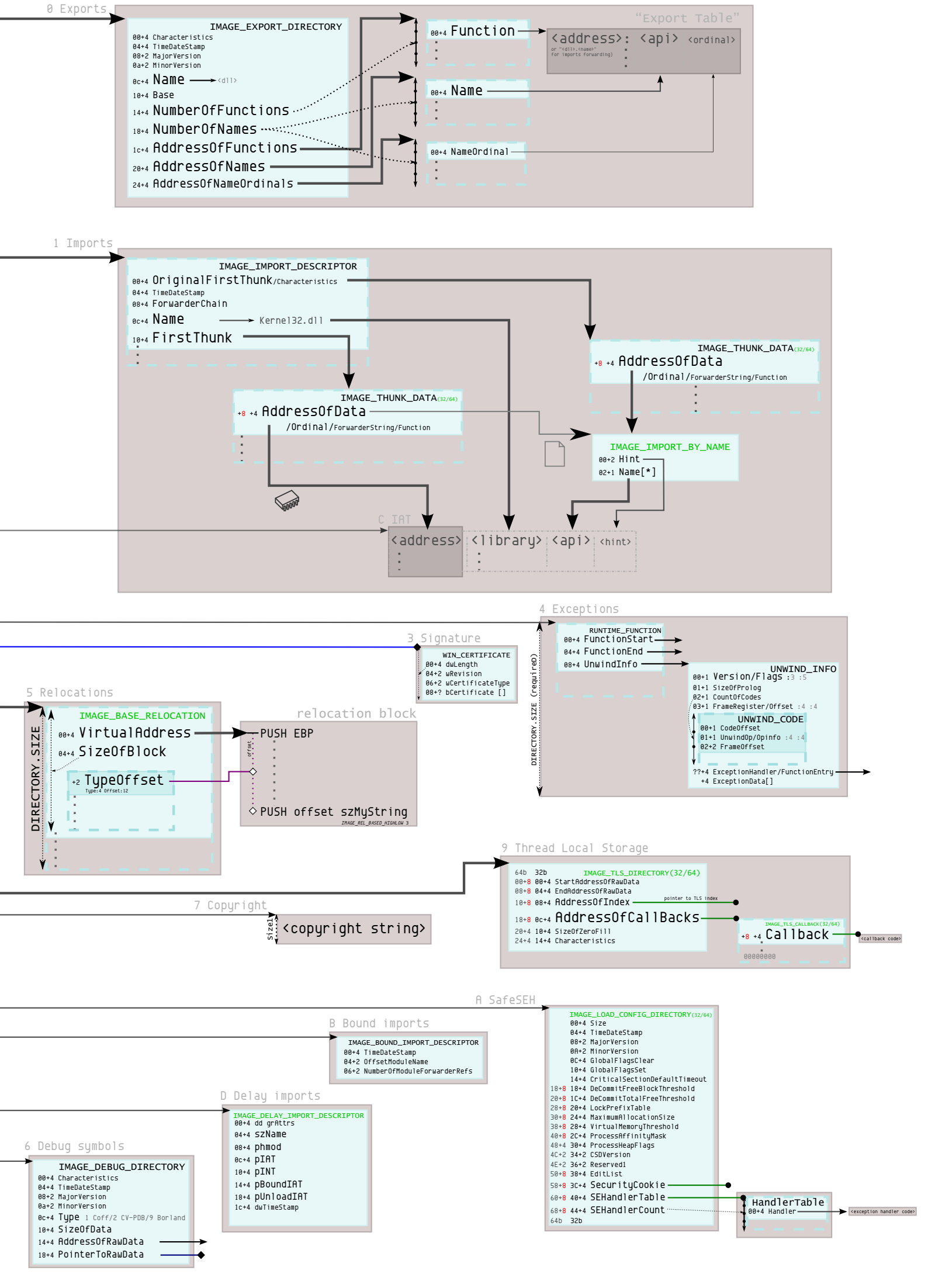
0 EXPORT
1 IMPORT
2 RESOURCE icons, manifest, version...
3 EXCEPTION 64bits exceptions
4 SECURITY Authenticode signature
5 BASERELOC relocations
6 DEBUG symbols
7 COPYRIGHT/Architecture useless
8 GLOBALPTR only on Itanium systems
9 TLS Thread Local Storage
A LOAD_CONFIG SafeSEH
B BOUND_IMPORT speeds up imports loading
C IAT Import Address table
D DELAY_IMPORT
E COM_DESCRIPTOR .NET header
F reserved unused
<ignored>...

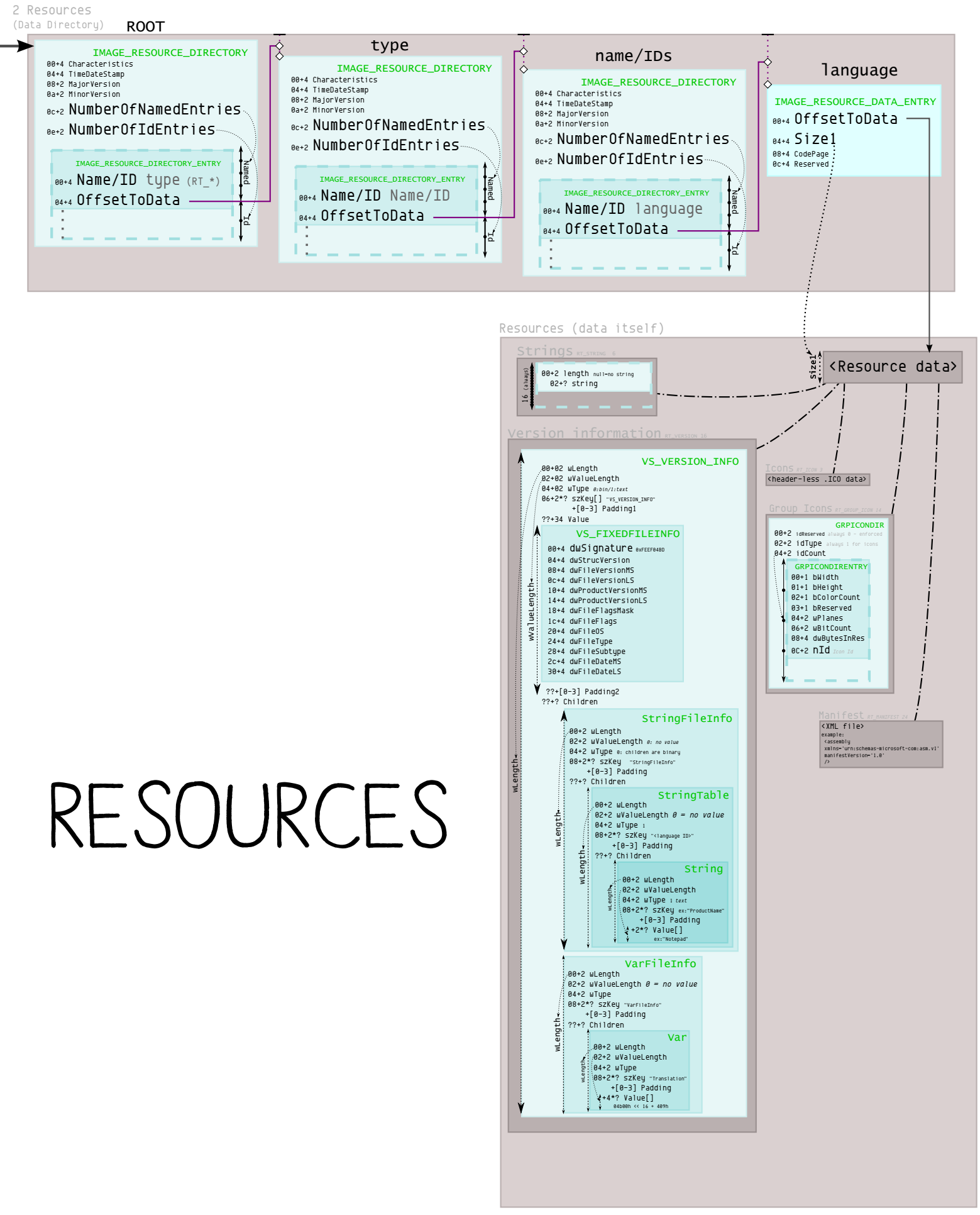
NumberOfSections

IMAGE_SECTION_HEADER

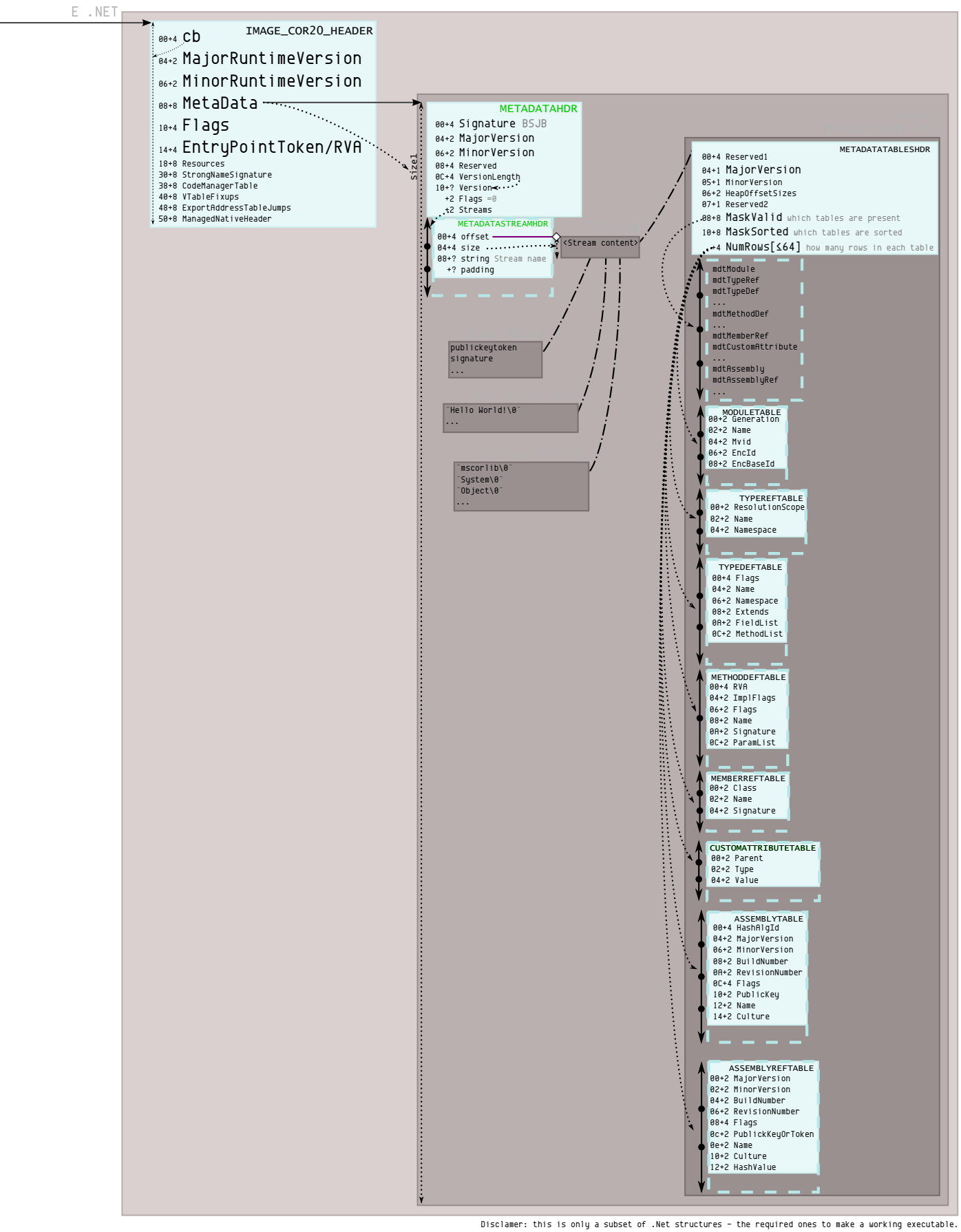
00+1 Name[8]
08+4 VirtualSize
0c+4 VirtualAddress → section start in memory
10+4 SizeOfRawData
14+4 PointerToRawData → section start in file
18+4 PointerToRelocations
1c+4 PointerToLinenumbers
20+2 NumberOfRelocations
22+2 NumberOfLinenumbers
24+4 Characteristics RWX

Section Table


0 Exports
IMAGE_EXPORT_DIRECTORY
00+4 Characteristics
04+4 TimeDateStamp
08+2 MajorVersion
0a+2 MinorVersion
0c+4 Name
<dll>
10+4 Base
14+4 NumberOfFunctions
18+4 NumberOfNames
1c+4 AddressOfFunctions
20+4 AddressOfNames
24+4 AddressOfNameOrdinals
00+4 Function
00+4 Name
00+4 NameOrdinal
"Export Table"
<address>: <api> <ordinal>
1 Imports
IMAGE_IMPORT_DESCRIPTOR
00+4 OriginalFirstThunk/Characteristics
04+4 TimeDateStamp
08+4 ForwarderChain
0c+4 Name
Kernel32.dll
10+4 FirstThunk
IMAGE_THUNK_DATA(32/64)
+8 +4 AddressOfData
/Ordinal/ForwarderString/Function
IMAGE_IMPORT_BY_NAME
00+2 Hint
02+1 Name[*]
C IAT
<address>
<library>
<api>
<hint>
4 Exceptions
RUNTIME_FUNCTION
00+4 FunctionStart
04+4 FunctionEnd
08+4 UnwindInfo
DIRECTORY.SIZE (required)
UNWIND_INFO
00+1 Version/Flags :3 :5
01+1 SizeOfProlog
02+1 CountOfCodes
03+1 FrameRegister/Offset :4 :4
UNWIND_CODE
00+1 CodeOffset
01+1 UnwindOp/Opinfo :4 :4
02+2 FrameOffset
??+4 ExceptionHandler/FunctionEntry
+4 ExceptionData[]
3 Signature
WIN_CERTIFICATE
00+4 dwLength
04+2 wRevision
06+2 wCertificateType
08+? bCertificate []
5 Relocations
IMAGE_BASE_RELOCATION
00+4 VirtualAddress
04+4 SizeOfBlock
+2 TypeOffset
Type:4 Offset:12
DIRECTORY.SIZE
relocation block
PUSH EBP
offset
PUSH offset szMyString
IMAGE_REL_BASED_HIGHLOW 3
9 Thread Local Storage
IMAGE_TLS_DIRECTORY(32/64)
64b 32b
00+8 00+4 StartAddressOfRawData
08+8 04+4 EndAddressOfRawData
10+8 08+4 AddressOfIndex
pointer to TLS index
18+8 0c+4 AddressOfCallBacks
20+4 10+4 SizeOfZeroFill
24+4 14+4 Characteristics
IMAGE_TLS_CALLBACK(32/64)
+8 +4 Callback
<callback code>
00000000
7 Copyright
Size1
<copyright string>
A SafeSEH
IMAGE_LOAD_CONFIG_DIRECTORY(32/64)
00+4 Size
04+4 TimeDateStamp
08+2 MajorVersion
0A+2 MinorVersion
0C+4 GlobalFlagsClear
10+4 GlobalFlagsSet
14+4 CriticalSectionDefaultTimeout
18+8 18+4 DeCommitFreeBlockThreshold
20+8 1C+4 DeCommitTotalFreeThreshold
28+8 20+4 LockPrefixTable
30+8 24+4 MaximumAllocationSize
38+8 28+4 VirtualMemoryThreshold
40+8 2C+4 ProcessAffinityMask
48+4 30+4 ProcessHeapFlags
4C+2 34+2 CSDVersion
4E+2 36+2 Reserved1
50+8 38+4 EditList
58+8 3C+4 SecurityCookie
60+8 40+4 SEHandlerTable
68+8 44+4 SEHandlerCount
64b 32b
HandlerTable
00+4 Handler
<exception handler code>
B Bound imports
IMAGE_BOUND_IMPORT_DESCRIPTOR
00+4 TimeDateStamp
04+2 OffsetModuleName
06+2 NumberOfModuleForwarderRefs
D Delay imports
IMAGE_DELAY_IMPORT_DESCRIPTOR
00+4 dd grAttrs
04+4 szName
08+4 phmod
0c+4 pIAT
10+4 pINT
14+4 pBoundIAT
18+4 pUnloadIAT
1c+4 dwTimeStamp
6 Debug symbols
IMAGE_DEBUG_DIRECTORY
00+4 Characteristics
04+4 TimeDateStamp
08+2 MajorVersion
0a+2 MinorVersion
0c+4 Type 1 Coff/2 CV-PDB/9 Borland
10+4 SizeOfData
14+4 AddressOfRawData
18+4 PointerToRawData


2 Resources
(Data Directory)
ROOT
IMAGE_RESOURCE_DIRECTORY
00+4 Characteristics
04+4 TimeDateStamp
08+2 MajorVersion
0a+2 MinorVersion
0c+2 NumberOfNamedEntries
0e+2 NumberOfIdEntries
IMAGE_RESOURCE_DIRECTORY_ENTRY
00+4 Name/ID type (RT_*)
04+4 OffsetToData
Named
Id
type
IMAGE_RESOURCE_DIRECTORY
00+4 Characteristics
04+4 TimeDateStamp
08+2 MajorVersion
0a+2 MinorVersion
0c+2 NumberOfNamedEntries
0e+2 NumberOfIdEntries
IMAGE_RESOURCE_DIRECTORY_ENTRY
00+4 Name/ID Name/ID
04+4 OffsetToData
Named
Id
name/IDs
IMAGE_RESOURCE_DIRECTORY
00+4 Characteristics
04+4 TimeDateStamp
08+2 MajorVersion
0a+2 MinorVersion
0c+2 NumberOfNamedEntries
0e+2 NumberOfIdEntries
IMAGE_RESOURCE_DIRECTORY_ENTRY
00+4 Name/ID language
04+4 OffsetToData
Named
Id
language
IMAGE_RESOURCE_DATA_ENTRY
00+4 OffsetToData
04+4 Size1
08+4 CodePage
0c+4 Reserved
Resources (data itself)
Strings RT_STRING 6
16 (always)
00+2 length null=no string
02+? string
Size1
<Resource data>
Version information RT_VERSION 16
VS_VERSION_INFO
00+02 wLength
02+02 wValueLength
04+02 wType 0:bin/1:text
06+2*? szKey[] "VS_VERSION_INFO"
+[0-3] Padding1
??+34 Value
wValueLength
VS_FIXEDFILEINFO
00+4 dwSignature 0xFEEF04BD
04+4 dwStrucVersion
08+4 dwFileVersionMS
0c+4 dwFileVersionLS
10+4 dwProductVersionMS
14+4 dwProductVersionLS
18+4 dwFileFlagsMask
1c+4 dwFileFlags
20+4 dwFileOS
24+4 dwFileType
28+4 dwFileSubtype
2c+4 dwFileDateMS
30+4 dwFileDateLS
??+[0-3] Padding2
??+? Children
wLength
StringFileInfo
00+2 wLength
02+2 wValueLength 0: no value
04+2 wType 0: children are binary
08+2*? szKey "StringFileInfo"
+[0-3] Padding
??+? Children
wLength
StringTable
00+2 wLength
02+2 wValueLength 0 = no value
04+2 wType 1
08+2*? szKey "<language ID>"
+[0-3] Padding
??+? Children
wLength
String
00+2 wLength
02+2 wValueLength
04+2 wType 1 text
08+2*? szKey ex:"ProductName"
+[0-3] Padding
+2*? Value[]
ex:"Notepad"
VarFileInfo
00+2 wLength
02+2 wValueLength 0 = no value
04+2 wType
08+2*? szKey "VarFileInfo"
+[0-3] Padding
??+? Children
wLength
Var
00+2 wLength
02+2 wValueLength
04+2 wType
08+2*? szKey "Translation"
+[0-3] Padding
+4*? Value[]
04b00h << 16 + 409h
Icons RT_ICON 3
<header-less .ICO data>
Group Icons RT_GROUP_ICON 14
GRPICONDIR
00+2 idReserved always 0 - enforced
02+2 idType always 1 for icons
04+2 idCount
GRPICONDIRENTRY
00+1 bWidth
01+1 bHeight
02+1 bColorCount
03+1 bReserved
04+2 wPlanes
06+2 wBitCount
08+4 dwBytesInRes
0C+2 nId Icon Id
Manifest RT_MANIFEST 24
<XML file>
example:
<assembly
xmlns='urn:schemas-microsoft-com:asm.v1'
manifestVersion='1.0'
/>

RESOURCES



Disclamer: this is only a subset of .Net structures - the required ones to make a working executable.

.NET