Windows API
Application Programming Interface

Technical knowledge for software engineers.

The **RogerVillela Journal (RVJ Services)** is a group of technical services with educational purpose. Among these professional services we have this free publication about Microsoft Windows programming environment concepts and the use of APIs. The purpose of this free publication is to put on the hands of the students, hobbyists, and professional software engineer's around the world, practical and objective knowledge of intermediate and advanced levels about Microsoft Windows operating system environment. All materials within this free publication are using C, C++ and Assembly programming languages, and are based on Intel IA-32 and Intel 64 (including x64) hardware architectures, and the technical knowledge about Common Language Runtime (CLR) and Windows Runtime (WinRT) execution environments inner workings are also included. The Microsoft development tools used are Microsoft Visual Studio integrated development environment (IDE) with Microsoft Visual C++ and Microsoft Windows SDK tools. For the IDE are used the sample solutions (.sln) and respective sample projects (.vcxproj). The Intel Parallel Studio with Intel C++ tools are also used in two forms, integrated with Microsoft Visual Studio and via command line. Initially, the knowledge areas of Microsoft Windows operating system covered by **RogerVillela Journal (RVJ)** are Windows Architecture and Engineering implementation, Memory Management, Processes and Threads, and Debugging resources. As C, C++ and Assembly programming languages are used for the sample projects, publications also have technical information about them, and C++/CLI projection for CLR execution environment and C++/CX for the WinRT execution environment, when applicable.

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Microsoft Windows OS

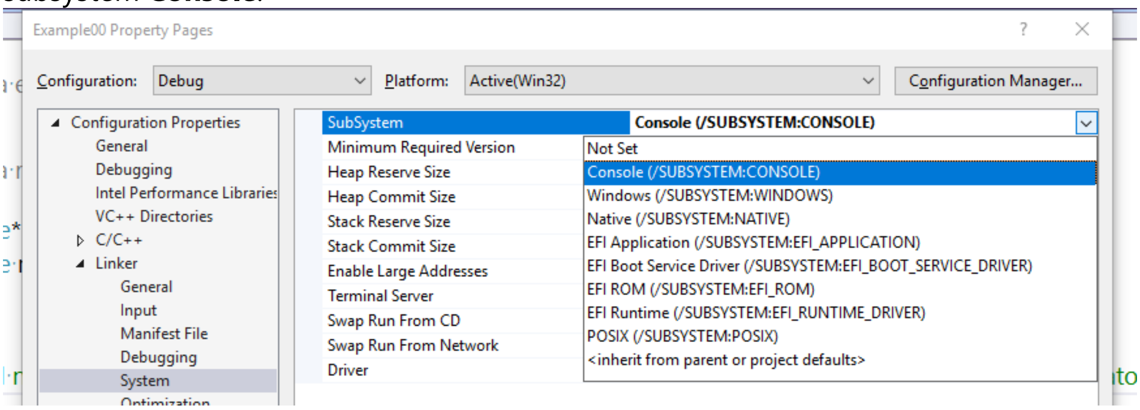
1. Introduction

Within each of this publication we have a group of lessons or experiments for the use in the process of learn about the Microsoft Windows software development using C++ programming language for who of you that are exploring how is the inner workings of these two technological contexts at intermediate and advanced level. We will learn that, despite the common perception that the only commercial valid investment is on most recent Microsoft Windows implementation versions, this is not the real life. We will see that even recent developed Application Programming Interfaces (API's) was made with support for Microsoft Windows 2000 or Microsoft Windows XP as the minimum implementation version that is supported by the API. The important commercial lesson here is that we have a broadly spectrum of Microsoft Windows implementation versions that we can offer services to and to obtain the return of our investments and be more profitable for our life plans, that certainly go through the professional area. Together, the C++ programming language and Microsoft Windows API put available this commercial opportunity.

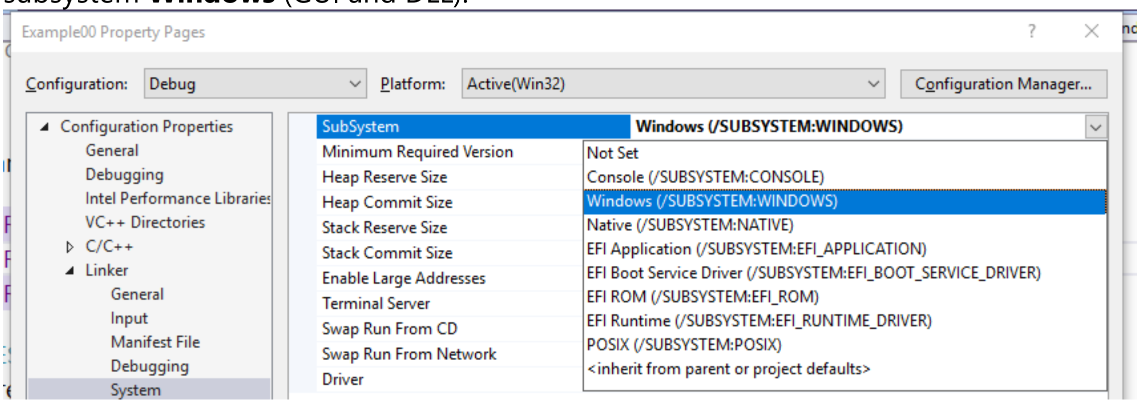
1.1 Sample solutions and projects

All code made available with the sample projects has demonstrative and educational purposes. They are used gradually to present concepts, syntactic/semantic resources, and technology resources. They are gradually changed and often according to their purpose in commercial products such as courses and sequence of free or marketed publications, such as books and changes in technologies.

Within this publication we have two sample solutions, the SecureZeroMemory and the IsWindows7SP1OrGreater. The SecureZeroMemory sample solution have one sample project named Example00, for the Microsoft Windows subsystem **Console**.



The IsWindows7SP1OrGreater sample solution have one sample project named Example00 for Microsoft Windows subsystem **Windows** (GUI and DLL).



For the sample solutions and sample projects, this publication is using Microsoft Visual Studio 2017 as starting point and will migrate to Microsoft Visual 2019 as soon as the RTM version is available. Despite of this fact, the **source code** in sample projects will compile in earlier versions of implementation of Microsoft C++ compiler, with changes where applicable and with the appropriate configured development environment. The source code files are created to shows Microsoft Windows features and details about the inner workings of it, with the practical and applicable purpose of expanding the knowledge of the people interested in this type of details, even if you are not a regular C++ programming language customer. For example, new features of C++ programming language are used and explained as appropriated, in more or less details, when in any source code file. One typical example is the use of the constant expression qualifier *constexpr (C++11/C++14)* that is supported by modern implementations of C++ compilers. If we are trying to offer support for an earlier implementation version of Microsoft C++ compiler that is based on a source code that is using the constant expression qualifier *constexpr*, we will need to do adjustments in our source code base so that it can offer support for both, the earlier Microsoft C++ compiler implementation version that does not offer the support for the constant expression qualifier *constexpr*, and more modern Microsoft C++ implementation version that offers support for the constant expression qualifier *constexpr*. This possible scenario of the use of the keywords *constexpr* and *const* should not be made via something like "text copy and replace" in anyway. We should use, for example, the #define macro directive and create something based on a business rule, like the Microsoft C++ implementation version. This excerpt of code shows an example of this possibility using #define directive in conjunction with a checking of the Microsoft Visual C++ implementation version and take a decision about the use of keywords *constexpr* or *const* when is Microsoft Visual Studio 2015 / Microsoft Visual C++ 2015 (1900) the minimum version being used for compilation. Using the automatically defined _MSC_VER macro we can check the Microsoft Visual C++ implementation version and define compatibility rules on our source code files:

```
#if _MSC_VER  >= 1900

#define CONSTEXPR

#if defined(CONSTEXPR)
#define CONST_OR_CONSTEXPR constexpr
#else
#define CONST_OR_CONSTEXPR const
#endif

#endif
```

So, this kind of information is also available within publications or within the source code file in most cases because it is more practical.

1.1.1 Windows API - Application Programming Interface sample solutions

- PATH(S)
    - **<install_folder>\RVJ\Platforms\Windows\Code**

- SOLUTIONS
    - **SYSTEM SERVICES - MEMORY MANAGEMENT - GENERAL**
        - **WE – Windows\Windows.System.MemoryManagement\General**
            - **C**

        - CopyMemory\CopyMemory.sln
    - **S**
        - **SecureZeroMemory\SecureZeroMemory.sln**

- **SYSTEM SERVICES – INFORMATION – VERSION HELPER FUNCTIONS**
  - **WE – Windows\Windows.System.Information**
    - **I**
        - **IsWindows7SP1OrGreater\IsWindows7SP1OrGreater.sln**

2. Windows API – Application Programming Interface

It is a public group of data types, data structures, and functions that we should use for developing our software components, software libraries and our software applications. An API is the public face of the complex engineering details for the inner workings of any software or hardware platform.

When working with Microsoft Windows API one of the first aspects are the various data types, data structures, functions and the concepts that are directly or indirectly associated with these elements. So, beginning from exploring some of the main header files of the Microsoft Windows API, helps us on acquiring knowledge of the standard elements, patterns and engineering implementation details of the infrastructure that are the base of any technology in Microsoft Windows operation system per se, also used for the implementation of specialized execution environments like CLR and WinRT, and other Microsoft products developed having Microsoft Windows operating system as platform, like Microsoft SQL Server, Microsoft Office 365, Microsoft Visual Studio, Microsoft Azure Cloud system, just to cite a few of them. As the Microsoft Windows operating system, the Windows API was conceived and constructed to be platform agnostic and to be updated over the time using this same principle. Currently, the Windows API have main support for 32-bit and 64-bit hardware platforms and their respective Microsoft Windows implementations, but in a not so distant time 😊, the Windows API also had support for 16-bit hardware platforms and the Microsoft Windows implementations. So, when we open and read any base header file of the Microsoft Windows API, we will find the use of **typedef** keyword of C/C++ programming languages for the definition of specific data types and data structures, and any of these is a *Windows Data Type*. The meaning of *windows data type* is used for data types and data structures that was designed, implemented and placed available to represent any part of the infrastructure of Microsoft Windows operating system, the high level specialized functionalities that are present, and that can be aggregated to the Microsoft Windows operating system. For example, we have fundamental *windows data types* like BOOL, BYTE, WORD, DWORD, INT, UINT, FLOAT, and even the VOID, and here is an excerpt of Microsoft Windows SDK header files with examples of fundamental *windows data types*:

```
typedef unsigned long DWORD;
typedef int BOOL;
typedef unsigned char BYTE;
typedef unsigned short WORD;
typedef float FLOAT;
typedef int INT;
typedef unsigned int UINT;
#ifndef VOID
#define VOID void
typedef char CHAR;
typedef short SHORT;
typedef long LONG;
#if !defined(MIDL_PASS)
typedef int INT;
#endif
#endif

//
// UNICODE (Wide Character) types
//
```

```
#ifndef _MAC
typedef wchar_t WCHAR; // wc, 16-bit UNICODE character
#else
//some Macintosh compilers don't define wchar_t in a convenient location, or define it as a char
typedef unsigned short WCHAR; // wc, 16-bit UNICODE character
#endif
```

We also have *windows data types* that are pointers to these other *windows data types*, and these are also defined using **typedef** keyword of C/C++ programming languages:

```
typedef FLOAT             *PFLOAT;
typedef BOOL near         *PBOOL;
typedef BOOL far          *LPBOOL;
typedef BYTE near         *PBYTE;
typedef BYTE far          *LPBYTE;
typedef int near          *PINT;
typedef int far           *LPINT;
typedef WORD near         *PWORD;
typedef WORD far          *LPWORD;
typedef long far          *LPLONG;
typedef DWORD near        *PDWORD;
typedef DWORD far         *LPDWORD;
typedef void far          *LPVOID;
typedef CONST void far    *LPCVOID;
typedef unsigned int      *PUINT;
```

(*) Do not worry about the words **near** and **far**, the purpose is related with the differences between 16-bit and 32-bit of Microsoft Windows implementation on 16-bit and 32-bit hardware platforms and will be explained through specialized topics on the publications about memory management. **The important to remember for now is that near and far ARE NOT KEYWORDS of Microsoft C/C++ implementations, are just macros defined in a header file of Microsoft Windows SDK.**

Opening the SecureZeroMemory sample solution and the main.cpp source code file of the Example00 sample project, we can find the use of *windows data types*, and as integrant of the Windows API for memory management, we have the SecureZeroMemory() function, part of the *General* category. It is defined with a return value of PVOID (pointer to void) *windows data type*, with the first parameter also using the PVOID (pointer to void) *windows data type*, and with the last parameter using the SIZE_T *windows data type*. The SIZE_T *windows data type* is defined as unsigned long for 32-bit platforms and unsigned __int64 for 64-bit platforms:

```
PVOID SecureZeroMemory( PVOID pointer, SIZE_T count );
```

In the signature of the *SecureZeroMemory() function* we have the PVOID and SIZE_T *windows data types*. The PVOID, as we can guess by name 😉, is a pointer to the **void** built-in fundamental type, that is part of the C/C++ programming languages. The PVOID *windows data type* is defined as:

```
typedef void *PVOID;
```

The SIZE_T *windows data type* is a **typedef** that is based on another windows data type, the **ULONG_PTR**.

```
// SIZE_T used for counts or ranges which need to span the range of a pointer.  SSIZE_T is the signed
// variation.
typedef ULONG_PTR SIZE_T, *PSIZE_T;
typedef LONG_PTR SSIZE_T, *PSSIZE_T;
```

The ULONG means unsigned long, a reference to its C/C++ fundamental base data type, and a description that helps known which base type is. The *windows data type* is defined for 32-bit and 64-bit implementations, depending on the target Microsoft Windows implementation. Here we have an excerpt of the block of code that defines the ULONG_PTR *windows data type*:

```
#if defined(_WIN64)
typedef unsigned __int64 ULONG_PTR, *PULONG_PTR;
#else
typedef _W64 unsigned long ULONG_PTR, *PULONG_PTR;
#endif
```

If the target implementation is a 64-bit Microsoft Windows implementation, the ULONG *windows data type* is defined as **unsigned __int64**. If the target implementation is a 32-bit Microsoft Windows implementation, the ULONG *windows data type* is defined as **unsigned long**.

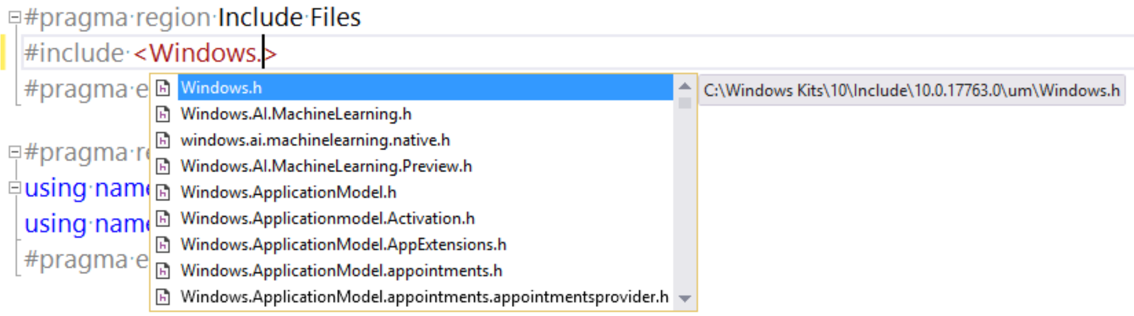
(*) The __int64 is a Microsoft-specific data type that is part of a group called *Microsoft sized integers*. For example, we have __int8, __int16, __int32 and the __int64 sized integer data types. These data types are supported only by Microsoft C/C++ compilers and the purpose is portability of the code. Obviously, if we are creating a source code base for work with different compilers, we will need to do an arrangement in the source code to check which is the compiler in use.

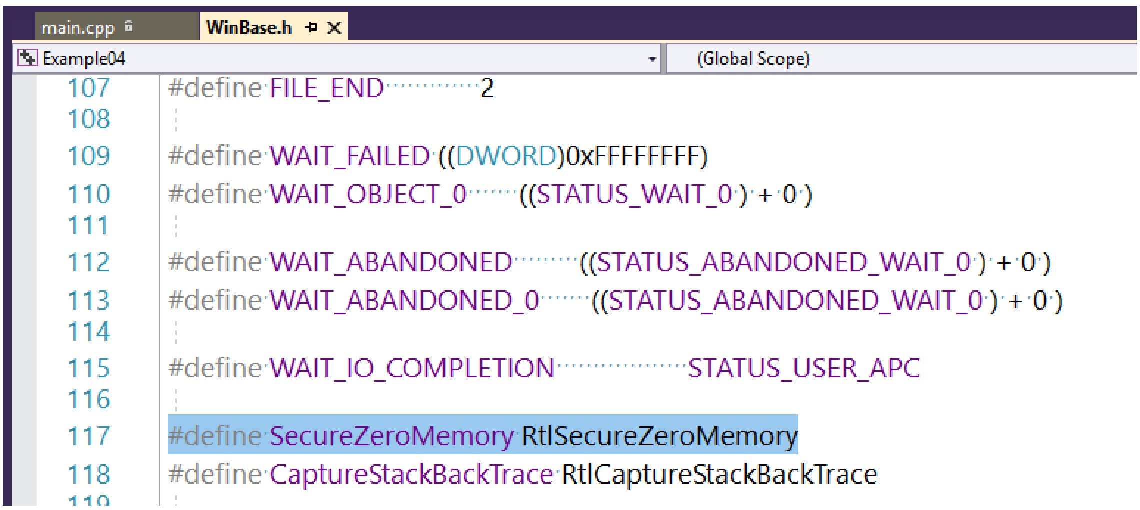
What we see here with these resources and features of compilers and programming languages, is a code implementation engineering technique for the creation of one or more layers of abstraction that helps us on the construction of the portability of large source code bases at various levels. For example, when reading Microsoft official documentation, we can find information on the bottom of the pages with resumed information about the supported Microsoft Windows implementations. Here we have an example for the *SecureZeroMemory Windows API function*:

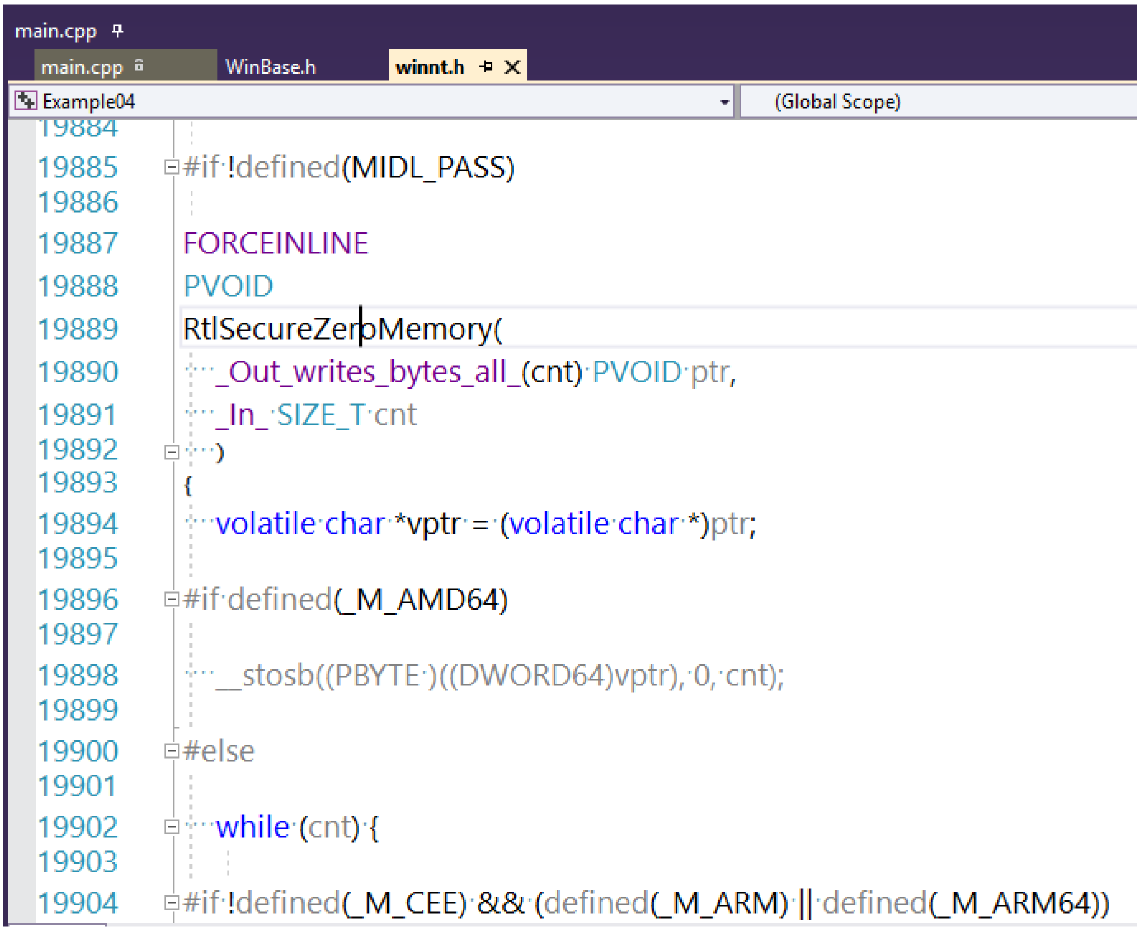
Requirements

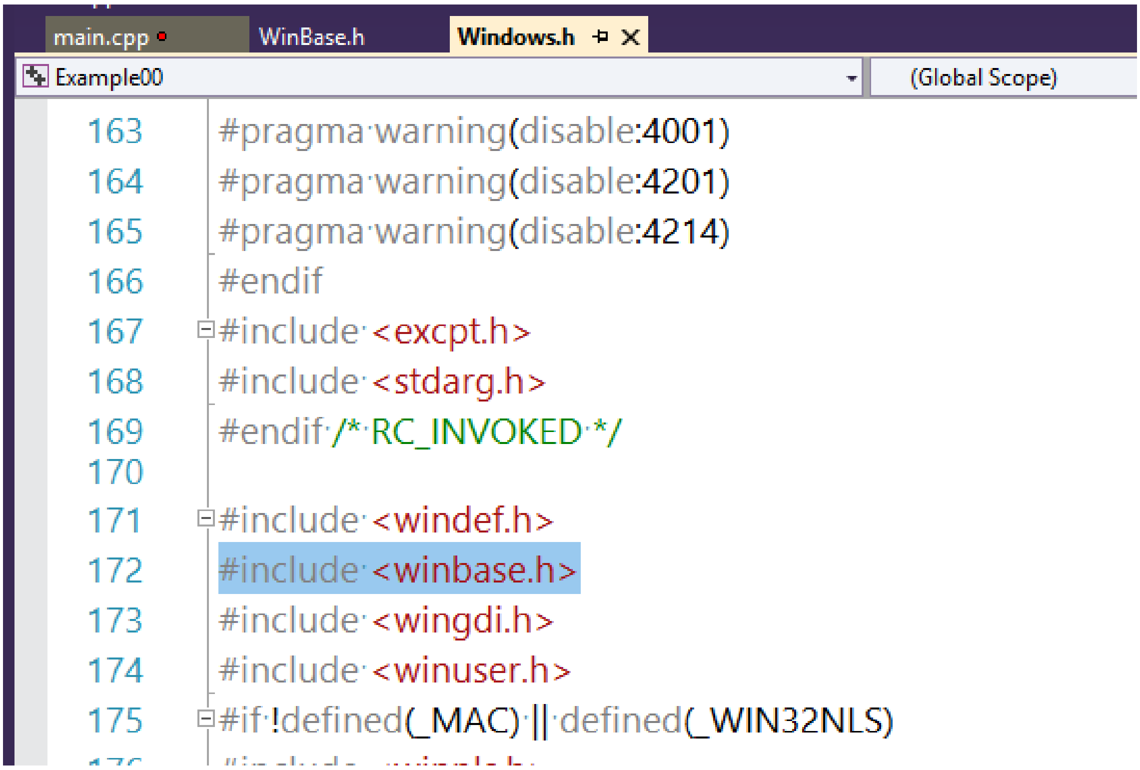
Minimum supported client	Windows XP [desktop apps only]
Minimum supported server	Windows Server 2003 [desktop apps only]
Header	WinBase.h (include Windows.h)

These are called **minimum requirements** and informs about the minimum client and minimum server that this Windows API element, the *SecureZeroMemory() function* in this example, are supported. These bottom page notes also inform the kind of **target environment** that this Windows API element is available for, and in this example the *SecureZeroMemory() function* can directly be used only within software applications that target the Microsoft Windows desktop environment. In this example, this means that the *SecureZeroMemory() function* cannot directly be used in a WinRT component source code or in an UWP software application source code. As final details, these bottom page notes also inform about the Microsoft Windows SDK header file that this function is declared or implemented depending of the case. In these information's about the *SecureZeroMemory() function*, it is declared within the *WinBase.h* header file that is included by *Windows.h* header file, and this means that we should access this function including *Windows.h* header file in our source code and not *WinBase.h* header file, except when explicitly indicated or required by the implementation model of the software component or software application. In these following images we can see the declaration of the *SecureZeroMemory() function*, in fact a macro, and an excerpt of the implementation, made by the *RtlSecureZeroMemory() function* in the *WinNT.h* header file. In the topic **About the SecureZeroMemory() function** we can find the details:






main.cpp
main.cpp
WinBase.h
winnt.h
Example04
(Global Scope)
#if !defined(MIDL_PASS)
FORCEINLINE
PVOID
RtlSecureZeroMemory(
_Out_writes_bytes_all_(cnt) PVOID ptr,
_In_ SIZE_T cnt
)
{
volatile char *vptr = (volatile char *)ptr;
#if defined(_M_AMD64)
__stosb((PBYTE)((DWORD64)vptr), 0, cnt);
#else
while (cnt) {
#if !defined(_M_CEE) && (defined(_M_ARM) || defined(_M_ARM64))


main.cpp
WinBase.h
Windows.h
Example00
(Global Scope)
#pragma warning(disable:4001)
#pragma warning(disable:4201)
#pragma warning(disable:4214)
#endif
#include <excpt.h>
#include <stdarg.h>
#endif /* RC_INVOKED */
#include <windef.h>
#include <winbase.h>
#include <wingdi.h>
#include <winuser.h>
#if !defined(_MAC) || defined(_WIN32NLS)

But returning to the main.cpp source code file of SecureZeroMemory->Example00 sample project, we can read the use of reinterpret_cast<T> (since C++98 with improvements introduced in C++11/C++17) keyword that is supported by modern C++ compiler implementations, and the use of the typical casting operation supported by C/C++ compiler implementations. If we are using an implementation of a C++ compiler that supports modern C++ features like reinterpret_cast<T> keyword, we should opt for it, else we can use the typical syntax for the cast operation. The fundamental purpose of reinterpret_cast<T> keyword is to help the compiler to understands and reinforce rules when working with pointer operations in scenarios where the bit patterns of pointer of type A should be converted to pointer of type B and understood as the pointer to type B from that point in execution scope. In the main.cpp source code file of the Example00 sample project, we have used the reinterpret_cast<T> with the typedef BaseType for the *standard C++* data type std::uint32_t, and with the *windows data type* PVOID:

```
typedef uint32_t BaseType;
BaseType x { 72ui32 };
BaseType* pointerToX { &x };


pointerToX = ( reinterpret_cast< BaseType* >( SecureZeroMemory( reinterpret_cast< PVOID >(
pointerToX ), ( ( SIZE_T ) sizeof( BaseType ) ) ) ));
```

If we had used the casting syntax for the two situations where the reinterpret_cast<T> keyword was used, it works as well, and the same block of code appears like this:

```
typedef uint32_t BaseType;
BaseType x { 72ui32 };
BaseType* pointerToX { &x };

pointerToX = ( ( BaseType* ) ( SecureZeroMemory( ( PVOID )( pointerToX ), ( ( SIZE_T ) sizeof(
BaseType ) ) ) ));
```

In this expression with the call for the *SecureZeroMemory() function*, the only cast that should be explicitly expressed is because of the return of the *SecureZeroMemory() function*, that is, the PVOID *windows data type*, in fact, a void* pointer, and the target pointer type pointerToX that is a pointer to BaseType*, in fact, a pointer to *C++ standard data type* std::uint32_t*. The other two parameters also need a cast operation, but to help in the productivity the Microsoft C/C++ compilers offers the implicit cast feature, and this means that where the compilers could find the necessity of a cast operation, it tries to resolve automatically. When the implicit cast operation was not possible to be applied by the Microsoft C/C++ compiler, we should explicitly inform via the appropriated syntax and data types. In our example, if the cast operation is applied where the reinterpret_cast<T> keyword appears, it works as well, and the same block of code appears like this:

```
typedef uint32_t BaseType;
BaseType x { 72ui32 };
BaseType* pointerToX { &x };

pointerToX = ( ( BaseType* ) ( SecureZeroMemory( ( pointerToX ),  sizeof( BaseType ) ) ) );
```

Maybe now we are asking why not use the C/C++ fundamental built-in data types and data structures like structs and classes? What is the reason to define new types for existing types or newly defined types?

Well, the primary answer here is portability.

Creating a gigantic product like an operating system requires that the design choices helps the **return of investment**, and an operating system is a **huge investment**, and we also have this type of design choices with the advanced data management platforms, like Microsoft SQL Server and Microsoft Azure Cosmos DB. For example, we can install the Microsoft SQL Server 2019 in a Microsoft Windows 10 Professional environment and in a Microsoft Windows Server 2019 Server, so, if we had created database tables, we can see the same fundamental data types on both installations of Microsoft SQL Server, and this same broadly available logic applies to queries and other data management objects that was made for this specialized data management platforms, of course we also have specialized product features that are made to work only in a specialized environment like the Microsoft Windows Server 2019, but this reflects how correctly the product was designed and implemented, separating technological features as the requirements of the client business expands. Using this abstract and broadly way of thinking, we have the motivation and the opportunity to create products that are more portable, and their functionalities will help on the return of the investments made on the platforms.

2.1 More Specialized Windows Data Types

As the following excerpts of code with the definitions for SYSTEMTIME, FILE_INFO_BY_HANDLE_CLASS, CREATE_THREAD_DEBUG_INFO and CREATE_PROCESS_DEBUG_INFO data structures show, we also have specialized data structures for more high level elements and functionalities of the Microsoft Windows operating system. In particular, the FILE_INFO_BY_HANDLE_CLASS shows another interesting aspect of the work with the Microsoft Windows API, how to deal with the improvements between Microsoft Windows implementations and differences in the data structures and data types. In the definition of FILE_INFO_BY_HANDLE_CLASS data structure we can read **#if** / **#endif** directives for checking the Microsoft Windows main version number of the implementation and depending of this information elements are included or not included. For example, if we are implementing a specific feature to be part of our software application or our software library that uses a data structure for a respective feature of Microsoft Windows operating system that has differences between Microsoft Windows operating system implementation versions, it is our responsibility to check the differences on the data structure for each version of Microsoft Windows and prepare our software application or software library to work with such requirements. In the following excerpts of code, we can see this behavior in the definition of the FILE_INFO_BY_HANDLE_CLASS data structure where these checks are made via **#if** / **#endif** directives in the source code base being compiled for. First, the FILE_INFO_BY_HANDLE_CLASS data structure is only defined if we are compiling for the _WIN32_WINNT_LONGHORN as the minimum Microsoft Windows implementation version, this signifies that this data structure does not exist in preceding Microsoft Windows implementation versions. The subsequent checks for the data structure use the **#if** / **#endif** directives to verifies if the Microsoft Windows implementation versions that we are compiling for, are _WIN32_WINNT_WIN8 or _WIN32_WINNT_WIN10_RS1 to includes certain fields and respective values:

```
#if (_WIN32_WINNT >= _WIN32_WINNT_LONGHORN)
typedef enum _FILE_INFO_BY_HANDLE_CLASS {
   FileBasicInfo,
   FileStandardInfo,
   FileNameInfo,
   FileRenameInfo,
   FileDispositionInfo,
   FileAllocationInfo,
   FileEndOfFileInfo,
   FileStreamInfo,
   FileCompressionInfo,
   FileAttributeTagInfo,
   FileIdBothDirectoryInfo,
   FileIdBothDirectoryRestartInfo,
   FileIoPriorityHintInfo,
   FileRemoteProtocolInfo,
   FileFullDirectoryInfo,
   FileFullDirectoryRestartInfo,
#if (_WIN32_WINNT >= _WIN32_WINNT_WIN8)
   FileStorageInfo,
   FileAlignmentInfo,
   FileIdInfo,
   FileIdExtdDirectoryInfo,
   FileIdExtdDirectoryRestartInfo,
#endif
```

```
#if (_WIN32_WINNT >= _WIN32_WINNT_WIN10_RS1)
    FileDispositionInfoEx,
    FileRenameInfoEx,
#endif
    MaximumFileInfoByHandleClass
} FILE_INFO_BY_HANDLE_CLASS, *PFILE_INFO_BY_HANDLE_CLASS;
#endif
```

As we have read about, for the agnostic and abstract purpose of the operating system and the API data types in respect of the hardware target platform's, the use of the typedef is a constant, even for data structures that represent concepts that are more common in our day life, but not less important, like the representation of the system date and time:

```
//
// System time is represented with the following structure:
//

typedef struct _SYSTEMTIME {
    WORD wYear;
    WORD wMonth;
    WORD wDayOfWeek;
    WORD wDay;
    WORD wHour;
    WORD wMinute;
    WORD wSecond;
    WORD wMilliseconds;
} SYSTEMTIME, *PSYSTEMTIME, *LPSYSTEMTIME;
```

Another important and interesting group with *windows data types* is that used for the support of the diagnostics of the applications and the environment around these, like the debugging activity. Different from what most people might think, the debugging features are not only available at specialized software development environments. Debugging is a feature available as part of the operating system services and can be used like any other functionality. Of course, certain features require a prepared development environment for debugging, but we can do a lot even without a disciplined specialized development environment for debugging. Independently of the level of the discipline used for the configuration with focus on diagnostics, the importance of it is reflected in the existence of the specialized data types, data structures and API's for the most fundamental operating system objects, like the process and the thread:

```
typedef struct _CREATE_THREAD_DEBUG_INFO {
   HANDLE hThread;
    LPVOID lpThreadLocalBase;
    LPTHREAD_START_ROUTINE lpStartAddress;
} CREATE_THREAD_DEBUG_INFO, *LPCREATE_THREAD_DEBUG_INFO;

typedef struct _CREATE_PROCESS_DEBUG_INFO {
    HANDLE hFile;
    HANDLE hProcess;
```

```
    HANDLE hThread;
    LPVOID lpBaseOfImage;
    DWORD dwDebugInfoFileOffset;
    DWORD nDebugInfoSize;
    LPVOID lpThreadLocalBase;
    LPTHREAD_START_ROUTINE lpStartAddress;
    LPVOID lpImageName;
    WORD fUnicode;
} CREATE_PROCESS_DEBUG_INFO, *LPCREATE_PROCESS_DEBUG_INFO;
```

These few examples of data structures are here to show the enormous and broadly spectrum covered by Microsoft Windows API, but it follows patterns since the conceptions until the implementation, because the Microsoft Windows API reflects the way of work of the Microsoft Windows operating system, so with each step in this tough learning curve, we are also learning about the inner workings of the architecture and implementation engineering of Microsoft Windows operating system.

3. About Microsoft Windows version number

This is critical to understands and accept, every aspect of the Microsoft Windows API reflects aspects and services (functionalities) of the Microsoft Windows operating system product implementations. So, if we try to include a data structure or data type that is not available or supported for such implementation, it is our fault and our responsibility for the consequences.

This topic is not an extensive discussion about the versioning mechanism of the Microsoft Windows operating system, but an introduction about aspects of the version numbers and the Windows API. The versioning is an extensive topic and when discussing about it we must include the CLR and WinRT, and this will be made gradually. 😉

Currently, the main version number of Microsoft Windows implementation is defined as simple macros via **#define** directive for hexadecimal numbers. We will find these patterns, that is, number values expressed in hexadecimal representation and associated with macros, not only within Microsoft Windows API, but for other Microsoft products and their respective C/C++ API's. Here we have examples of these number values expressed in hexadecimal representation and their associated macros:

```
//
//_WIN32_WINNT version constants
//
#define _WIN32_WINNT_NT4                    0x0400
#define _WIN32_WINNT_WIN2K                  0x0500
#define _WIN32_WINNT_WINXP                  0x0501
#define _WIN32_WINNT_WS03                   0x0502
#define _WIN32_WINNT_WIN6                   0x0600
#define _WIN32_WINNT_VISTA                  0x0600
#define_WIN32_WINNT_WS08                    0x0600
#define _WIN32_WINNT_LONGHORN               0x0600
#define _WIN32_WINNT_WIN7                   0x0601
#define _WIN32_WINNT_WIN8                   0x0602
#define _WIN32_WINNT_WINBLUE                0x0603
#define _WIN32_WINNT_WINTHRESHOLD           0x0A00 /* ABRACADABRA_THRESHOLD*/
#define _WIN32_WINNT_WIN10                  0x0A00 /* ABRACADABRA_THRESHOLD*/
```

The use of this programming technique using **#if** / **#endif** directives is applied at compile time ⌚, as we see in the definition of FILE_INFO_BY_HANDLE_CLASS enum. But we can also use a checking of "*which is*" the Microsoft Windows implementation version at run-time using Microsoft Windows API functions and data structures designed and implemented specifically for this task, like the new **Version Helper functions** of the Microsoft Windows API. The version helper functions are defined in the **versionhelpers.h** header file, and it was first distributed with Microsoft Windows SDK for Microsoft Windows 8.1. But the **versionhelpers.h** can also be used with projects that target earlier versions Microsoft Windows and support Microsoft Windows 2000 Professional or Microsoft Windows 2000 Server as the minimum Microsoft Windows implementations. If we look inside the **versionhelpers.h** header file, we will find various "Is" functions, like IsWindowsXPOrGreater(), IsWindowsXPSP1OrGreater(), IsWindows7OrGreater(), IsWindows7SP1OrGreater(), IsWindows10OrGreater(). Currently, except the IsWindowsServer() function that explicitly calls VerifyVersionInfo() function that is part of the Windows API, all these "Is" functions, calls just one function, the

IsWindowsVersionOrGreater(), that also is part of the source code in the **versionhelpers.h** header file. Here is the full implementation of IsWindowsXPOrGreater() as is currently in the **versionhelpers.h** header file:

```
VERSIONHELPERAPI IsWindowsXPOrGreater() {

return IsWindowsVersionOrGreater(HIBYTE(_WIN32_WINNT_WINXP),
LOBYTE(_WIN32_WINNT_WINXP), 0);

};
```

The IsWindowsVersionOrGreater() function is a kind of "all-in-one" function, that is, the other functions inform the same sequence of parameters but with different argument values for each specific Microsoft Windows version that is interested in. Internally, the "all-in-one" IsWindowsVersionOrGreater() function calls the VerifyVersionInfo() function that is part of Windows API and that is available since Microsoft Windows 2000, Professional and Server. Here is the full implementation of IsWindowsVersionOrGreater() as is currently in the **versionhelpers.h** header file:

```
VERSIONHELPERAPI IsWindowsVersionOrGreater(WORD wMajorVersion, WORD wMinorVersion,
WORD wServicePackMajor) {

   OSVERSIONINFOEXW osvi = { sizeof(osvi), 0, 0, 0, 0, {0}, 0, 0 };
   DWORDLONG  const dwlConditionMask = VerSetConditionMask( VerSetConditionMask(
VerSetConditionMask( 0, VER_MAJORVERSION, VER_GREATER_EQUAL), VER_MINORVERSION,
VER_GREATER_EQUAL), VER_SERVICEPACKMAJOR, VER_GREATER_EQUAL);

osvi.dwMajorVersion = wMajorVersion;
osvi.dwMinorVersion = wMinorVersion;
osvi.wServicePackMajor = wServicePackMajor;

return VerifyVersionInfoW(&osvi, VER_MAJORVERSION | VER_MINORVERSION |
VER_SERVICEPACKMAJOR, dwlConditionMask) != FALSE;
};
```

If we open the IsWindows7SP1OrGreater sample solution and the main.cpp source code file of the Example00 sample project we can find an example of the use of IsWindows7SP1OrGreater() version helper function. In fact, this sample project is a kind of "Hello, World of Microsoft Windows", but using the GDI/GDI+ GUI.

4. About the SecureZeroMemory function

```
PVOID SecureZeroMemory( _In_ PVOID ptr, _In_ SIZE_T cnt );
```

The technical purpose of implementation of the **SecureZeroMemory() function** is to assign the zero value for each byte in a memory block and it is a safer implementation of the macro **ZeroMemory**. In fact, the **SecureZeroMemory is a macro for the RtlSecureZeroMemory() function.**

```
#define SecureZeroMemory RtlSecureZeroMemory
```

The implementation of the RtlSecureZeroMemory() function is provided inline.

```
FORCEINLINE PVOID RtlSecureZeroMemory( PVOID ptr, _In_ SIZE_T cnt );
```

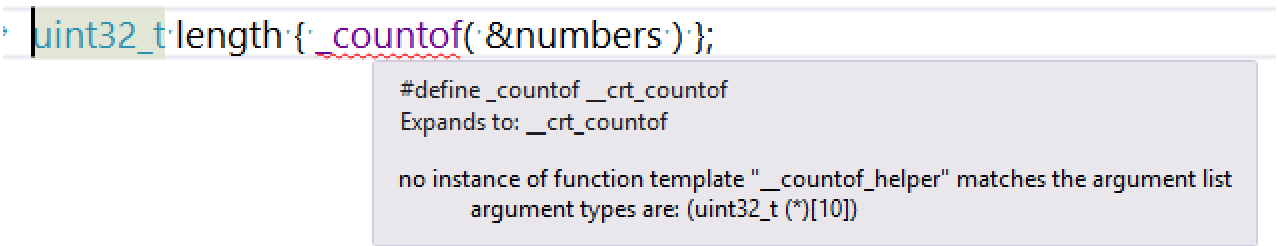
FORCEINLINE is a macro for the instruction __forceinline or __inline**.** The __inline and inline specifiers instructs the compiler to insert a copy of the body of the function instead of making the call. This means that the block of code in the assembly that represents the function is inserted into each location where a call occurs for that function. When applied to a function, the __inline or inline specifiers, this does not mean that an automatic expansion occurs. The cost and benefit assessment of the expansion is accomplished by the compiler. When applied the __forceinline specifier, it is not the compiler that performs the evaluation but who wrote the code. That is, this overlaps the compiler's analysis criterion and assumes the cost and benefit criterion of whoever wrote the code correctly. The definition of the macro FORCEINLINE includes a version check from Microsoft Visual Studio. The definition uses the MSC_VER macro to verify that Microsoft Visual Studio used to compile the project is greater than or equal to Microsoft Visual Studio 2013. If positive, uses __forceinline, otherwise use __inline. But even though they seem like orders, __forceinline and __inline are suggestions for the compiler and can be ignored in the same way.

```
#ifndef FORCEINLINE
   #if (_MSC_VER >= 1200)
     #define FORCEINLINE __forceinline
   #else
      #define FORCEINLINE __inline
   #endif
#endif
```

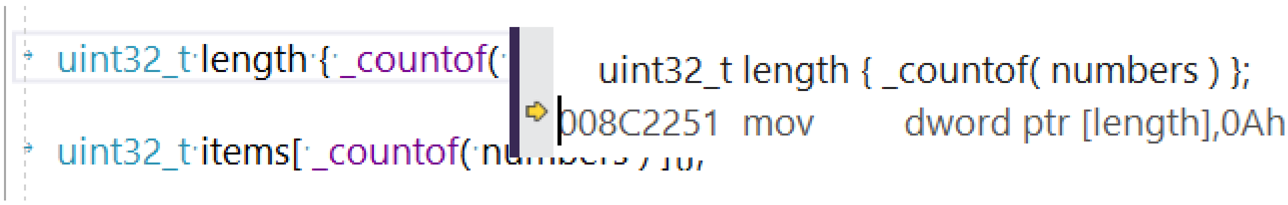
It is important to remember that many of these functions, such as **RtlSecureZeroMemory() function**, are provided **inline** only when compiled in RELEASE mode. But **RtlSecureZeroMemory() function** is provided **inline** in DEBUG mode and in RELEASE mode. During the compilation process, the compilers perform a process called "optimization", and this "optimization" means the identification of an inefficient code pattern and substitution by a more efficient and safe code pattern. For the **ZeroMemory() function**, this optimization means that the compiler removes the calls to **ZeroMemory() function** and includes other code that performs the same function. If the use of **ZeroMemory() function** is critical to the application, is recommended to use the **SecureZeroMemory() function** instead of the **ZeroMemory() function**. The **SecureZeroMemory() function** is safer and currently it is not removed by the compilers. The use of **SecureZeroMemory() function** is recommended for use with dynamically allocated memory blocks and not for use with typical variables, however, the macro can also be used with statically allocated arrays, for example. The total number of bytes that all the elements in a static array occupy, can be obtained using the sizeof operator.

```
uint32_t* pointerToNumbers{};
uint32_t numbers[]{ {}, 1ui32, 2ui32, 3ui32, 4ui32, 5ui32, 6ui32, 7ui32, 8ui32, 9ui32 };
uint32_t totalOfBytes{ sizeof( numbers ) };
```

These two expressions calculate the total number of elements that exist in a statically allocated array. The second is a macro of the UCRT/CRT that does the same task, but in recent C++ implementations of Microsoft UCRT/CRT the macro is using a template-based implementation instead of more direct expression, like the first example. One advantage in the use of a template-based implementation is that helps the compiler in a more precising data type checking, for example, if we try to pass a pointer as argument value instead of an array, the compiler can check this even before the compilation, and with the direct expression, the compiler cannot does this, and we will get a runtime error of address access violation.



The result of the _countof macro is a constant value because the macro only can be used with statically allocated arrays. And when we look in the assembly code, we can read the constant value, in this example 0Ah, for the number of the elements:



And the new array called *items* initialized with the number of elements informed by the constant value resultant of the **_countof** macro call:

```
    uint32_t items[ _countof( numbers ) ]{};
008C2258  xor         eax,eax
008C225A  mov         dword ptr [items],eax
008C2260  mov         dword ptr [ebp-98h],eax
008C2266  mov         dword ptr [ebp-94h],eax
008C226C  mov         dword ptr [ebp-90h],eax
008C2272  mov         dword ptr [ebp-8Ch],eax
008C2278  mov         dword ptr [ebp-88h],eax

    uint32_t items[ _countof( numbers ) ]{};
008C227E  mov         dword ptr [ebp-84h],eax
008C2284  mov         dword ptr [ebp-80h],eax
008C2287  mov         dword ptr [ebp-7Ch],eax
008C228A  mov         dword ptr [ebp-78h],eax
```

So, when developing using C++ programming language, the recommendation is the use of the **_countof** macro, instead of a direct expression:

```
uint32_t length{ sizeof ( numbers ) / sizeof ( numbers[ 0ui32 ] ) };
```

```
uint32_t length{ _countof( numbers ) };
```

```
Console::WriteLine( u"Number of bytes: %u\n\n", totalOfBytes );
Console::WriteLine( u"(BEFORE) numbers\n\n" );
```

Displays the contents of the array before using **SecureZeroMemory**.

```
uint32_t index{};
```

```
for ( ; index != length; index++ ) Console::WriteLine( u"[ %u ]: %u\n", index, numbers[ index ] );
```

Uses **SecureZeroMemory** in the array.

```
pointerToNumbers = ( reinterpret_cast< uint32_t* >( SecureZeroMemory( reinterpret_cast< PVOID >( numbers ), ( ( SIZE_T ) totalOfBytes ) ) ) );
```

The *ptr* parameter is a pointer to the memory address where the buffer that must be filled starts. "First position" is a relative concept because the "start" may be different from the "zero" position. The *cnt* parameter indicates how many bytes should receive the value 0 (zero).

What does the SecureZeroMemory macro returns?

Returns a pointer to the buffer, that is, the function returns a pointer to the address that was informed as the argument value to the *ptr* parameter. But in the signature of the function, the return is of the PVOID type, that is a typedef for a void * (void pointer), and PVOID type is defined in the header file **Winnt.h** as follows:

```
typedef void *PVOID;
```

Because a void pointer (*void) can point to any type there is no way to know which type is returned. Then we must perform the casting for the expected type as a return.

If everything worked out, displays the contents of the array, displays the memory addresses of the pointer returned by **SecureZeroMemory**, which is the memory address of the array numbers.

```
if ( ( pointerToNumbers != nullptr ) && ( pointerToNumbers == numbers ) ) {
```

OU

```
if ( ( pointerToNumbers ) && ( pointerToNumbers == numbers ) ) {
        Console::WriteLine( u"\npointerToNumbers: %#0x\n" "numbers: %#0x\n", pointerToNumbers, numbers );
```

Displays the contents of the array after using **SecureZeroMemory**.

```
Console::WriteLine( u"\n(AFTER) numbers\n\n" );

for ( index = {}; index != length; index++ ) Console::WriteLine( u"[ %u ]: %u\n", index, numbers[ index ] );
 };

pointerToNumbers = nullptr;
```

4.1 Recommendations

Even though the SecureZeroMemory macro is referenced in the Microsoft official documentation as a function, it is a macro for a real implementation function, called RtlSecureZeroMemory() function, and this is another characteristic of the Microsoft Windows API. Today this rarely used, if it is, in modern API's of the Microsoft Windows operating system, but we will find this kind of construction for scenarios like with SecureZeroMemory macro. This is a not a "bad" thing per se, it is a just a possibility available via the programming language. Unfortunately, radical views that are against of this kind of programming construction, could lead to source code bases to ignore the use of the SecureZeroMemory macro and chooses to directly call of the RtlSecureZeroMemory. It is important to be aware that there is no checking by compiler part to something like this, and for the compiler tools, at least until now, it is just another call for a normal function of a library, so, nothing wrongs will happen, and this works normally. But, as SecureZeroMemory macro is created as the public face of the RtlSecureZeroMemory() function, we should respect this structure and purpose used by the Microsoft Windows API. If you are in doubt about the meaning of the **Rtl**, it is **Run-time Library**. However, in specific scenarios we will see that the non-use of programming constructions like SecureZeroMemory macro is not only a recommendation, but it is a requirement. The code used on the development of kernel-mode device drivers, is one of these scenarios. In fact, the use of any kind of code for work at kernel context, is an extremely performance sensitive kind of code and shall follows more disciplined implementation strategies. We can learn more about the use of RtlSecureZeroMemory() function for kernel-mode device drivers, and kernel-mode code in general, reading the Microsoft official documentation for device drivers' development:

https://docs.microsoft.com/en-us/windows-hardware/drivers/ddi/content/wdm/nf-wdm-rtlsecurezeromemory

In this page of the Microsoft official documentation for the use of the RtlSecureZeroMemory() function on the development of device drivers, we can read at bottom of the web page in the **Requirements** section, more detailed information about the RtlSecureZeroMemory() function. If we look at **Wdm.h** header file that is part of the Microsoft Windows Driver Development Kit, we will not find any declaration for a SecureZeroMemory macro, but only the definition of the RtlSecureZeroMemory() function :

Minimum supported client	Available in Windows Server 2003 and later versions of Windows. (Because the routine is declared inline, the body of the routine can be included in earlier versions of the operating system.)
Target Platform	Desktop
Header	wdm.h (include Wdm.h, Ntddk.h, Ntifs.h)
IRQL	Any level (See Remarks section)

Here is the implementation as is in the Wdm.h header file:

```
FORCEINLINE
PVOID
RtlSecureZeroMemory(
    _Out_writes_bytes_all_(cnt) PVOID ptr,
    _In_ SIZE_T cnt
```

```
    )
{
    volatile char *vptr = (volatile char *)ptr;

#if defined(_M_AMD64)

    __stosb((PUCHAR)((ULONG64)vptr), 0, cnt);

#else

    while (cnt) {

#if !defined(_M_CEE) && (defined(_M_ARM) || defined(_M_ARM64))

        __iso_volatile_store8(vptr, 0);

#else

        *vptr = 0;

#endif

        vptr++;
        cnt--;
    }

#endif // _M_AMD64

    return ptr;
}
```

Run-time Library routines: **https://docs.microsoft.com/en-us/windows-hardware/drivers/ddi/content/_kernel/#run-time-library-rtl-routines**

5. The notorious "Hello, World!", but using GDI/GDI+

No presentation text about software programming is complete without the notorious "Hello, World!" program. But in our case, we have a different "Hello, World!" and it is based on the GDI/GDI+ graphical API. When working with .NET platform, we known about the GDI/GDI+ when we are using the Microsoft Windows Forms that is part of the .NET Framework Class Library (FCL). This example is left here to be our starting point for the next publication. For now, you can do experiments with the source code and explore the concepts that we are talking about in this publication. You should be conscious that the use of aspects of the GDI/GDI+ graphical system API is not to explain graphical programming, but infrastructure functionalities of the Microsoft Windows operating system like the *message queue system* used for communication of events between applications and the operating system specialized services, and this is valid for other graphics system used by sample projects like WPF, UWP / WinRT or DirectX platform's. Using this "Hello, World!" as base code, we also begin to explore aspects of process, threads and memory management.

Our "Hello, World!" is in fact the sample project Example00 that is part of the sample solution IsWindows7SP1OrGreater. We will use this structure of source code for examples from now on, and since the February / 2019 publication, we will begin to explore aspects of GDI/GDI+, or other graphical system, but keeping the focus on the purpose of the publication and not as guide for the graphical programming features of the GDI/GDI+ API or any other graphical system supported by Microsoft Windows operating system. In February / 2019 we also introduce the construction of Dynamic-link library (DLL) as part of reorganization of the structure of the sample project. Here we have all the source code that is organized in three files, Example00.h, Button.cpp and main.cpp. This sample project compiles and runs "correctly" but has intentional bugs. One of the bugs is in the main.cpp source code file, more specifically in the processing of the **WM_PAINT window message**. If you have a basic experience with GDI/GDI+ you can opt by doing the necessary adjustment. If you are not interested in doing this now, you can comment all the source code for the processing **WM_PAINT window message** and the visible GUI bug will disappear. In the Button.cpp, for the **WM_PARENTNOTIFY and WM_CREATE window messages**, the source code is incomplete, and you can opt to include experimental code. There are other types of bugs, but they need knowledge about Microsoft Windows operating system inner workings to understands "the why?". Anyway, all these bugs will be fixed and required concepts explained through the publications, beginning with publication of February / 2019.

5.1 Example00.h header file

```
#pragma once


#pragma region Header files
#include <RVJ.Desktop.h>
#pragma endregion

#pragma region Use of constexpr where possible instead of const
/*

If the minimum MSVC (Microsoft Visual C++) is 1900, that is, Microsoft Visual C++ that is distributed with
Microsoft Visual Studio 2015, use constexpr where supported by the compiler.

*/
```

```
#if _MSC_VER  >= 1900

#define CONSTEXPR

#if defined(CONSTEXPR)
#define CONST_OR_CONSTEXPR constexpr
#else
#define CONST_OR_CONSTEXPR const
#endif

#endif

#pragma endregion

#pragma region String messages
CONST_OR_CONSTEXPR LPCWSTR MessageCaption { L"IsWindows7SP1OrGreater" };
CONST_OR_CONSTEXPR LPCWSTR MessageText { L"We are running on Microsoft Windows 7 Service Pack 1 or greater." };
#pragma endregion

#pragma region Constants for DPI manipulation
CONST_OR_CONSTEXPR int32_t Standard_96DPI { 96i32 };
#pragma endregion

LRESULT ManageButton( HWND hWindow, UINT message, WPARAM wParam, LPARAM lParam );
BOOL CALLBACK ManagedChildWindows( HWND, LPARAM );
```

5.2 Button.cpp

```
#pragma region Header Files
#include <RVJ.Desktop.h>
#include "Example00.h"
#pragma endregion



LRESULT ManageButton( HWND hWindow, UINT message, WPARAM wParam, LPARAM lParam ) {

	CONST_OR_CONSTEXPR SIZE_T MaxClassNameSize { 80ui32 };
	CONST_OR_CONSTEXPR WCHAR* ButtonClassName { L"Button" };
	CONST_OR_CONSTEXPR SIZE_T paintstructSize { sizeof( PAINTSTRUCT ) };

	LPCREATESTRUCT localStruct {};
	LRESULT result {};
```

```
            LPWSTR windowClassName { reinterpret_cast< LPWSTR >( HeapAlloc( GetProcessHeap(),
HEAP_ZERO_MEMORY, MaxClassNameSize ) ) };
            bool validClassName { ( GetClassName( hWindow, windowClassName, MaxClassNameSize ) > 0i32 )
};

            switch ( message ) {

                        case WM_PARENTNOTIFY: {

                                    switch ( LOWORD( wParam ) ) {

                                                case WM_CREATE: {

                                                            HWND childHandle = reinterpret_cast<HWND>(  lParam );

                                                            localStruct = reinterpret_cast< LPCREATESTRUCT >( lParam );

                                                            if ( validClassName ) {

                                                                        /*

                                                                        If it is a BUTTON window, adapt the size to content.

                                                                        */

                                                                        if ( !wcscmp( windowClassName, ButtonClassName ) )
{

                                                                                    LPPAINTSTRUCT paintStruct {
reinterpret_cast< LPPAINTSTRUCT >( HeapAlloc( GetProcessHeap(), HEAP_ZERO_MEMORY, paintstructSize ) )
};
                                                                                    /*HDC deviceContext { BeginPaint(
hWindow, paintStruct ) };*/

                                                                                    /*EndPaint( hWindow, paintStruct );*/

                                                                                    HeapFree( GetProcessHeap(), {},
reinterpret_cast< LPVOID >( paintStruct ) );

                                                                                    paintStruct = nullptr;

                                                                                    result = FALSE;

                                                                        };
```

```
                                }; }; break;

                            default: break;
                        };

                }; break;

                default: break;
        };

        HeapFree( GetProcessHeap(), {}, reinterpret_cast< LPVOID >( windowClassName ) );
        windowClassName = nullptr;

        return result;

};
```

5.3 main.cpp

```
#ifdef __INTEL_COMPILER
#pragma warning( disable: 1079; )
#endif

#pragma region Header Files
#include <RVJ.Desktop.h>
#include "Example00.h"
#pragma endregion

#pragma region Namespaces
using namespace std;
#pragma endregion


LRESULT CALLBACK WndProc( HWND hWindow, UINT message, WPARAM wParam, LPARAM lParam ) {

        CONST_OR_CONSTEXPR SIZE_T MaxClassNameSize { 80ui32 };
        CONST_OR_CONSTEXPR WCHAR* ButtonClassName { L"Button" };
        CONST_OR_CONSTEXPR char16_t* const defaultWindowText { u"Hello, Microsoft Windows 10!" };

        LRESULT processResult {};

        switch ( message ) {

                case WM_CREATE: {
```

```
            LPWSTR windowClassName { reinterpret_cast< LPWSTR >( HeapAlloc(
GetProcessHeap(), HEAP_ZERO_MEMORY, MaxClassNameSize ) ) };
            bool validClassName { ( GetClassName( hWindow, windowClassName,
MaxClassNameSize ) > 0i32 ) };

            HeapFree( GetProcessHeap(), {}, reinterpret_cast< LPVOID >( windowClassName )
);

            windowClassName = nullptr;

        };
                        break;


        case WM_SIZE: {

            RECT clientRect {};

            GetClientRect( hWindow, &clientRect );

            EnumChildWindows( hWindow, &ManagedChildWindows, ( LPARAM )
&clientRect );

            processResult = FALSE;

        }; break;

        case WM_PARENTNOTIFY: {


            processResult = ManageButton( hWindow, message, wParam, lParam );



        };  break;

        case WM_COMMAND: {

            if ( HIWORD( wParam ) == BN_CLICKED ) {

                if ( IsWindows7SP1OrGreater() ) MessageBox( nullptr, MessageText,
MessageCaption, MB_OK );

            };

            processResult = FALSE;

        }; break;
```

```
};

        case WM_PAINT: {

            CONST_OR_CONSTEXPR  SIZE_T rectSize { sizeof( RECT ) };
            CONST_OR_CONSTEXPR  SIZE_T paintstructSize { sizeof( PAINTSTRUCT ) };
            HANDLE const processHeap { GetProcessHeap() };

            LPPAINTSTRUCT ps { reinterpret_cast< LPPAINTSTRUCT >( HeapAlloc( processHeap,
            HEAP_ZERO_MEMORY, paintstructSize ) ) };
            LPRECT        rect { reinterpret_cast< LPRECT >( HeapAlloc( processHeap,
            HEAP_ZERO_MEMORY, rectSize ) ) };

            HDC        hdc { BeginPaint( hWindow, ps ) };

            GetClientRect( hWindow, rect );


            DrawText( hdc, reinterpret_cast< LPCWSTR >( defaultWindowText ), -1i32, rect,
                DT_SINGLELINE | DT_CENTER | DT_VCENTER );

            EndPaint( hWindow, ps );

            SecureZeroMemory( reinterpret_cast< PVOID >( ps ), paintstructSize );
            HeapFree( processHeap, {}, reinterpret_cast< LPVOID >( ps ) );
            ps = nullptr;

            SecureZeroMemory( reinterpret_cast< PVOID >( rect ), rectSize );
            HeapFree( processHeap, {}, reinterpret_cast< LPVOID >( rect ) );
            rect = nullptr;


        }; break;


        case WM_CLOSE: DestroyWindow( hWindow ); break;

        case WM_DESTROY: {

                PostQuitMessage( 0i32 );

        }; break;
    };

    processResult = DefWindowProc( hWindow, message, wParam, lParam );

    return processResult;
};
```

```
BOOL CALLBACK ManagedChildWindows( HWND handle, LPARAM lParam ) {

	BOOL result {};
	LPRECT clientRect { reinterpret_cast< LPRECT >( lParam ) };
	UINT dpiForWindow { GetDpiForWindow( handle ) };
	int32_t dpiX { MulDiv( ( clientRect->right >> 1i32 ), dpiForWindow, Standard_96DPI ) };
	int32_t dpiY { MulDiv( ( clientRect->bottom >> 1i32 ), dpiForWindow, Standard_96DPI ) };
	int32_t dpiWidth { MulDiv( 200, dpiForWindow, Standard_96DPI ) };
	int32_t dpiHeight { MulDiv( 100, dpiForWindow, Standard_96DPI ) };

	SetWindowPos( handle, nullptr, dpiX, dpiY, dpiWidth, dpiHeight, SWP_NOZORDER |
SWP_NOACTIVATE );
	//MoveWindow( handle, ( clientRect->right >> 1i32 ), ( clientRect->bottom >> 1i32 ), 200, 100,
TRUE );

	result = ShowWindow( handle, SW_SHOW );

	return result;
};

int WINAPI WinMain( _In_ HINSTANCE hThisInstance, _In_ HINSTANCE hPrevInstance,
	_In_opt_ LPSTR szCmdLine, _In_ int iCmdShow ) {

	CONST_OR_CONSTEXPR char16_t* const applicationName { u"HelloWindowClass" };
	CONST_OR_CONSTEXPR char16_t* const windowCaption { u"The Hello Program" };
	CONST_OR_CONSTEXPR SIZE_T wndclassSizeInBytes { sizeof( WNDCLASSEX ) };
	CONST_OR_CONSTEXPR SIZE_T msgSizeInBytes { sizeof( MSG ) };

	int32_t messageResult {};

	HANDLE const defaultProcessHeap { GetProcessHeap() };
	HWND		hWindow {};
	LPMSG		message { reinterpret_cast< LPMSG >( HeapAlloc( defaultProcessHeap,
HEAP_ZERO_MEMORY, msgSizeInBytes ) ) };
	LPWNDCLASSEX	windowClass { reinterpret_cast< LPWNDCLASSEX >( HeapAlloc(
defaultProcessHeap, HEAP_ZERO_MEMORY, wndclassSizeInBytes ) ) };

	#pragma region Task 00 - Create main window.

	windowClass->cbSize = wndclassSizeInBytes;
	windowClass->style = ( CS_HREDRAW | CS_VREDRAW );
	windowClass->lpfnWndProc = &WndProc;
	/*windowClass->cbClsExtra = 0;
	windowClass->cbWndExtra = 0;*/
	windowClass->hInstance = hThisInstance; /* Instance of process. */
```

```
	windowClass->hIcon = reinterpret_cast< HICON >( LoadImage( nullptr, IDI_APPLICATION,
IMAGE_ICON, {}, {}, LR_DEFAULTSIZE | LR_LOADMAP3DCOLORS | LR_LOADTRANSPARENT ) );
	windowClass->hCursor = reinterpret_cast< HCURSOR >( LoadImage( nullptr, IDC_ARROW,
IMAGE_CURSOR, {}, {}, LR_DEFAULTSIZE | LR_LOADMAP3DCOLORS | LR_LOADTRANSPARENT ) );
	windowClass->hbrBackground = reinterpret_cast< HBRUSH >( GetStockObject( WHITE_BRUSH ) );
	/*windowClass->lpszMenuName = nullptr;*/
	windowClass->lpszClassName = reinterpret_cast< LPCWSTR >( applicationName );

	if ( !RegisterClassEx( reinterpret_cast< WNDCLASSEX const * >( windowClass ) ) ) {
		MessageBox( nullptr, TEXT( "This program requires Microsoft Windows NT!" ),
			reinterpret_cast< LPCWSTR >( applicationName ), MB_ICONERROR );
	} else {


		hWindow = CreateWindowEx( {}, reinterpret_cast< LPCTSTR >( applicationName ),
			reinterpret_cast< LPCTSTR >( windowCaption ),
			WS_OVERLAPPEDWINDOW | WS_HSCROLL | WS_VSCROLL,
			CW_USEDEFAULT,
			CW_USEDEFAULT,
			CW_USEDEFAULT,
			CW_USEDEFAULT,
			nullptr,
			nullptr,
			hThisInstance,
			nullptr );

		#pragma endregion

		#pragma region Task 01 - Create child window.

		CreateWindowEx( {}, reinterpret_cast< LPCWSTR >( L"Button" ),
			reinterpret_cast< LPCWSTR >( windowCaption ),
			WS_TABSTOP | WS_CHILDWINDOW | BS_PUSHBUTTON,
			CW_USEDEFAULT,
			CW_USEDEFAULT,
			CW_DEFAULT,
			CW_DEFAULT,
			hWindow,
			nullptr,
			hThisInstance,
			nullptr );

		#pragma endregion

		ShowWindow( hWindow, iCmdShow );
		/*
		AnimateWindow( hWindow, 200i32, AW_BLEND | AW_ACTIVATE | AW_SLIDE );
```

```
                    AnimateWindow( hWindow, 200i32, AW_HOR_POSITIVE );
                    AnimateWindow( hWindow, 200i32, AW_HOR_NEGATIVE );
                    AnimateWindow( hWindow, 200i32, AW_SLIDE );
                    AnimateWindow( hWindow, 200i32, AW_VER_POSITIVE );
                    AnimateWindow( hWindow, 200i32, AW_VER_NEGATIVE );
                    */
                    UpdateWindow( hWindow );


                    while ( messageResult = GetMessage( reinterpret_cast< LPMSG >( message ), nullptr,
0ui32, 0ui32 ) ) {
                              TranslateMessage( reinterpret_cast< MSG* >( message ) );
                              DispatchMessage( reinterpret_cast< MSG* >( message ) );
                    };

          };

          DestroyIcon( windowClass->hIcon );
          DestroyCursor( windowClass->hCursor );

          windowClass = reinterpret_cast< LPWNDCLASSEX >( SecureZeroMemory( reinterpret_cast< LPVOID
>( windowClass ), wndclassSizeInBytes ) );

          HeapFree( defaultProcessHeap, {}, reinterpret_cast< LPVOID >( message ) );
          HeapFree( defaultProcessHeap, {}, reinterpret_cast< LPVOID >( windowClass ) );

          message = nullptr;
          windowClass = nullptr;
          const_cast< HANDLE >( defaultProcessHeap ) = nullptr;

          return messageResult;

};
```

See you on February / 2019! 😉