Writing
Debugger Extensions

Microsoft CPR Summit, 2007

Presented by :

T.Roy

CodeMachine Inc.

www.codemachine.com

Speaker Introduction

- T.Roy
  - Masters in Computer Engineering
  - 20 years experience in system software development
  - 10 years international teaching experience
  - Specialization in Windows Driver Development and Debugging
  - Founder of CodeMachine
- CodeMachine Inc.
  - Consulting and Training Company
  - Based in Palo Alto, CA, USA
  - Custom Driver Development and Debugging Services
  - Corporate on-site training in Windows Internals, Networking, Device Drivers and Debugging
  - http://www.codemachine.com

CodeMachine Courses

- **Internals Track**
  - **Windows User Mode Internals**
  - **Windows Kernel Mode Internals**
- **Debugging Track**
  - **Windows Basic Debugging**
  - **Windows User Mode Debugging**
  - **Windows Kernel Mode Debugging**
- **Development Track**
  - **Windows Network Drivers**
  - **Windows Kernel Software Drivers**
  - **Windows Kernel Filter Drivers**
  - **Windows Driver Model (WDM)**
  - **Windows Driver Framework (KMDF)**

Agenda

- **Debugger Extension Environment**
- **Debugger Extension Interface**
- **Debugger Extension Implementation**

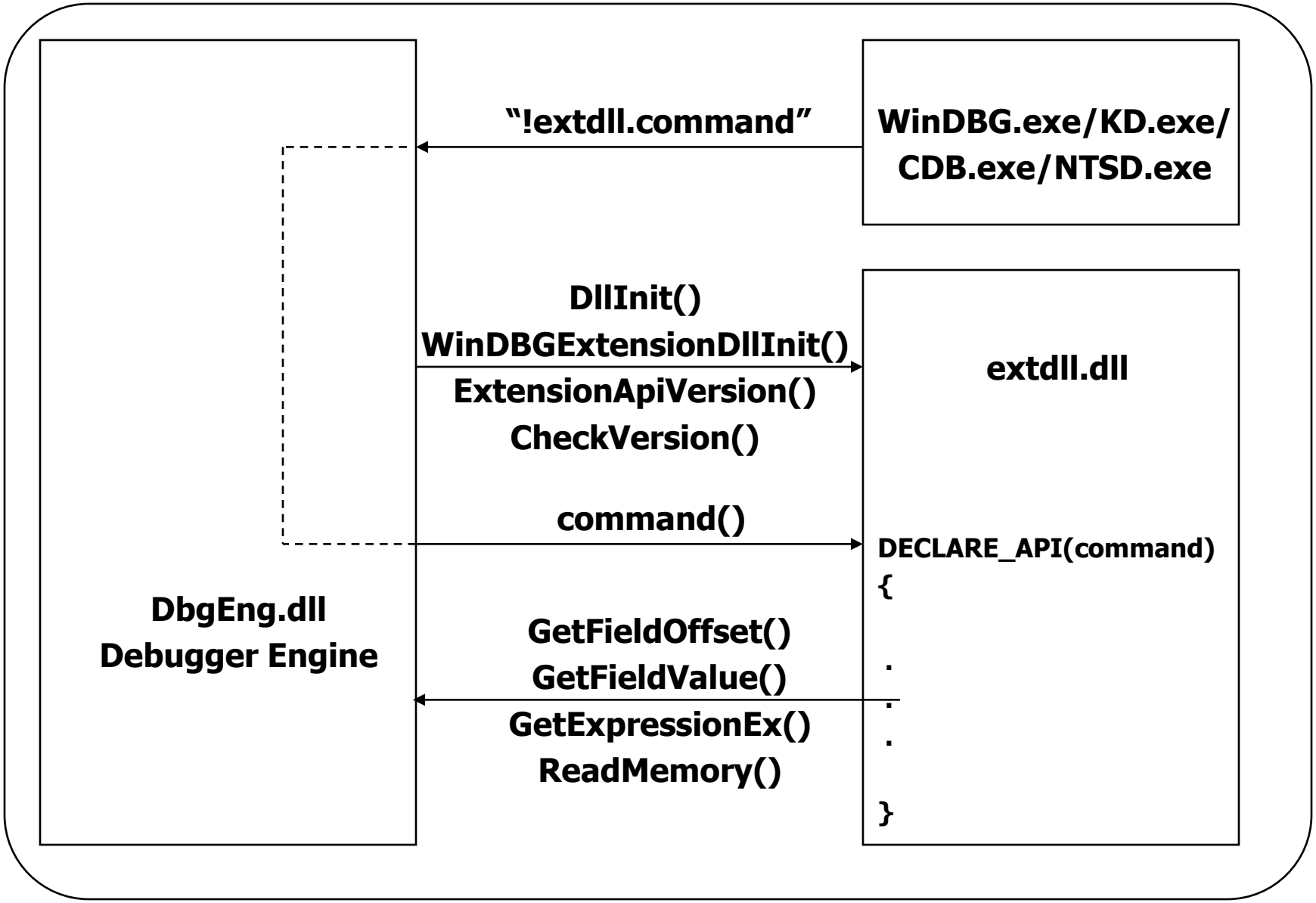
Debugger Extension DLLs

- Any task performed in the debugger that is repetitive can be automated by debugger extension DLLs
- Extension DLLs read data from the target system or process, parse the data and display it in an easily readable format
- Extension DLL Architecture
  - Win32/Win64 DLLs that run in the debugger's process context
  - Implements special entry points as required by debugger engine
  - Uses the debugger engine API and symbol handler API
  - Commands supported by extension DLLs are implemented as DLL exports
- Extension DLL programming considerations
  - Debugger Extensions run "in-proc"
    - Debugger uses exception handler around extensions to recover from AVs
  - Perform all target data access through the debugger engine APIs
    - Cannot used standard Win32 APIs to access data on the debug target since this does not work on crash dumps
  - Must handle Ctrl-Break to return control to debugger engine
    - Debugger cannot stop extension code while it is executing

Build Environment

- Software Requirements
  - Windows Driver Kit
    - Required for build tools, compiler, linker etc
  - Debugger Package
    - Required for header files, libraries and sample code
    - Perform "custom" installation of debugger and select SDK
  - Debugger Extension documentation is included in debugger help file
- Building Extension DLLs
  - Open a WDK build window (command prompt)
  - In the build window set the following environment variables
    - DBGSDK_INC_PATH=C:\WinDBG\sdk\inc
    - DBGSDK_LIB_PATH=C:\WinDBG\sdk\lib
  - Change to the directory containing the 'sources' file for the debugger extension DLL
  - Type 'build –cW' at the command prompt
  - Copy the .dll file to %WinDBG%\winext directory
  - Type '!DllName.command' at the debugger prompt to run commands from the extension DLL
  - To unload an extension DLL use the command ".unload DLLName"

Debugger Extension Interface



Debugger Extension - Template Code

- **Header Files**

```
#include <windows.h>
#include <wdbgexts.h>
#include <ntverp.h>
```

- **Declare Globals**

```
EXT_API_VERSION        ApiVersion = { (VER_PRODUCTVERSION_W >> 8),
    (VER_PRODUCTVERSION_W & 0xff),        EXT_API_VERSION_NUMBER64, 0 };
WINDBG_EXTENSION_APIS   ExtensionApis;
```

- **Initialization Callback**

```
VOID WinDbgExtensionDllInit( PWINDBG_EXTENSION_APIS lpExtensionApis,
       USHORT MajorVersion,  USHORT MinorVersion ) {
       ExtensionApis = *lpExtensionApis;
}
```

- **Version Query Callback**

```
LPEXT_API_VERSION ExtensionApiVersion( VOID) {
    return &ApiVersion;
}
```

- **Version Check Callback**

```
VOID CheckVersion ( VOID) {
}
```

- **DLL Entry Point**

```
BOOLEAN DllInit ( HMODULE Module, DWORD Reason, DWORD Reserved ) {
    return TRUE;
}
```

Debugger Extension – Common Tasks

- **Querying global variables**

```
if ( GetExpressionEx("nt!NtBuildNumber", &dwBuildNumber, NULL ) != TRUE ) {
    dprintf("Error reading nt!BuildNumber\n" );
}
```

- **Reading field offsets of a structure**

```
GetFieldValue ( IrpPointer, "_IRP", "Tail.Overlay.CurrentStackLocation",  pIOSL );
```

- **Reading field offsets of a structure**

```
if( GetFieldOffset ( "_EPROCESS", "ActiveThreadLink", &ActiveThreadLinkOffset ) ) {
    dprintf("Error reading _EPROCESS->ActiveThreadLink\n" );
}
```

- **Reading Virtual Address Space**

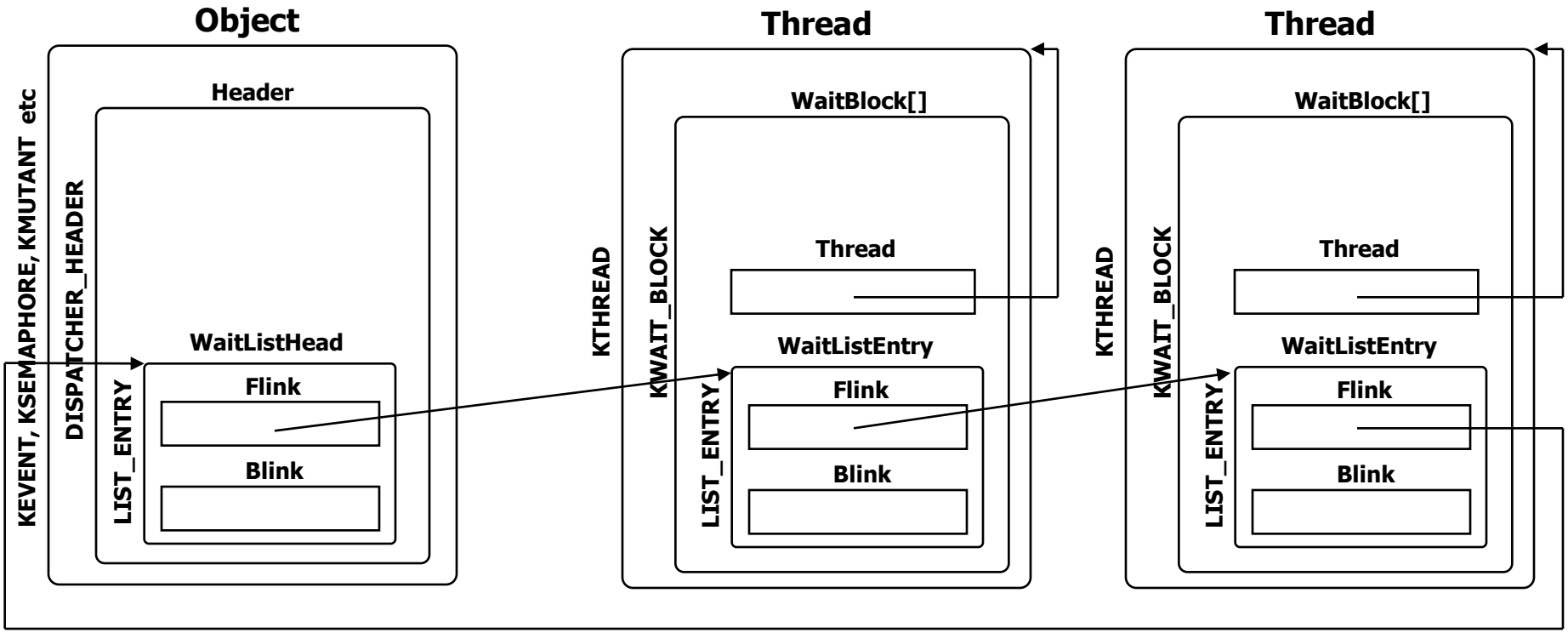
```
if ( ReadMemory ( VirtualAddress, &Buffer, sizeof(Buffer), &BytesReturned) != TRUE ) {
    dprintf("Error reading memory @ %p\n", VirtualAddress );
}
```

Debugger Extension - Example

- Implement a debugger extension which displays a list of threads waiting on a dispatcher object
  - List of threads is maintained in a doubly linked list whose list head is in the dispatcher object
  - Extension DLL needs to traverse this doubly linked list and print information about each thread it finds
- Capability to parse doubly linked lists can be applied to many data structures e.g.
  - List of processes in system
  - List of threads in a process
  - List of IRPs per thread
- Debugger extension (myexts.dll) should support 2 commands
  - !help – will display the list of commands and parameters
  - !waitlist <object> – will display the list of threads waiting on the object
- Debugger extension should use the simple 'C' API provides in the header file sdk\inc\wdbgexts.h
- Debugger extension should run unmodified on 64-bit targets

Waiting Threads

- Dispatcher objects contain the DISPATCHER_HEADER structure
  - WaitListHead is the head of the list of threads waiting on an object
- Threads contain a set of KWAIT_BLOCK structures
  - WaitListEntry is used to queue the thread to the object it is waiting for
- 'dt' command can walk this chain of waiting threads
  - dt nt!_KEVENT <ObjectAddress> Header.WaitListHead.Flink
  - dt nt!_KWAIT_BLOCK <Flink> -l WaitListEntry.Flink Thread



Debugger Extension – File Manifest

sources

```
TARGETNAME=myexts
TARGETPATH=obj
TARGETTYPE=DYNLINK
DLLENTRY=_DllMainCRTStartup
TARGETLIBS=$(SDK_LIB_PATH)\kernel32.lib
USE_MSVCRT=1
UMTYPE=windows
SOURCES=exts.cpp
```

myexts.def

```
EXPORTS
        help
        waitlist
        CheckVersion
        WinDbgExtensionDllInit
        ExtensionApiVersion
```

makefile

```
!INCLUDE $(NTMAKEENV)\makefile.def
```

myexts.cpp

```
. . .
DECLARE_API ( help ) {
        dprintf (
                "  waitlist - Prints a list of threads waiting on an object\n"
                "  help     - Prints this help\n" );
}
. . .
```

myexts.cpp – waitlist Command

```
DECLARE_API( waitlist )
{
        ULONG WaitListHeadOffset, WaitListEntryOffset;
        ULONG64 Object;

        if  ( ( Object = GetExpression(args) ) == 0 ) {
                dprintf("Usage: !waitlist <dispatcher-object>\n");
                return;
        }

        if( GetFieldOffset ( "nt!_DISPATCHER_HEADER", "WaitListHead", &WaitListHeadOffset ) ) {
                return;
        }

        if( GetFieldOffset ( "nt!_KWAIT_BLOCK", "WaitListEntry", &WaitListEntryOffset ) ) {
                return;
        }

        dprintf ( "Object %p WaitList:\n", Object );
        dprintf ( "%8s %6s %6s %8s %8s %8s %8s %3s\n",
                "ETHREAD", "Pid", "Tid", "WaitTime", "KrnlApc", "SpclApc", "CombApc", "CPU" );

        ParseLinkedList ( Object + WaitListHeadOffset, EntryCallback, WaitListEntryOffset, NULL );
}
```

myexts.cpp – Double Link List Parsing

```
BOOLEAN ParseLinkedList  (
        ULONG64 ListHead, PLIST_CALLBACK Function,
        ULONG FieldOffset, PVOID Context ) {

        LIST_ENTRY64 ListEntryHead, ListEntryCurrent;
        ULONG64 ListCurrent;

        ReadListEntry ( ListHead, &ListEntryHead );

        for (ListCurrent = ListEntryHead.Flink ;
                ListCurrent != ListHead ;
                ListCurrent = ListEntryCurrent.Flink ) {

                ReadListEntry ( ListCurrent, &ListEntryCurrent );

                if ( ! Function ( ListCurrent - FieldOffset, Context ) ) {
                        return FALSE;
                }
                if ( CheckControlC () ) {
                        return FALSE;
                }
        }
        return TRUE;
}
```

```
typedef
BOOLEAN
(*PLIST_CALLBACK) (
  ULONG64 Address,
  PVOID Context );
```

myexts.cpp – waitlist Callback

```
BOOLEAN EntryCallback ( ULONG64 WaitBlock, PVOID Context )
{
        ULONG64 Thread, Pid, Tid;
        ULONG WaitTime, KernelApcDisable, SpecialApcDisable,CombinedApcDisable;
        UCHAR IdealProcessor;

        GetFieldValue(WaitBlock, "nt!_KWAIT_BLOCK", "Thread", Thread );
        GetFieldValue(Thread, "nt!_ETHREAD", "Cid.UniqueProcess", Pid );
        GetFieldValue(Thread, "nt!_ETHREAD", "Cid.UniqueThread", Tid );
        GetFieldValue(Thread, "nt!_ETHREAD", "Tcb.WaitTime", WaitTime );
        GetFieldValue(Thread, "nt!_ETHREAD", "Tcb.KernelApcDisable", KernelApcDisable );
        GetFieldValue(Thread, "nt!_ETHREAD", "Tcb.SpecialApcDisable", SpecialApcDisable );
        GetFieldValue(Thread, "nt!_ETHREAD", "Tcb.CombinedApcDisable", CombinedApcDisable );
        GetFieldValue(Thread, "nt!_ETHREAD", "Tcb.IdealProcessor", IdealProcessor );

        dprintf ( "%8p %6I64x %6I64x %8u %8s %8s %8s %3u\n",
                Thread, Pid, Tid, WaitTime,
                KernelApcDisable ? "DISABLED" : "ENABLED",
                SpecialApcDisable ? "DISABLED" : "ENABLED",
                CombinedApcDisable ? "DISABLED" : "ENABLED",
                IdealProcessor );

        return TRUE;
}
```