

UEFI & EDK II Training

EDK II Debugging

tianocore.org



Lesson Objective

- ★ Define DebugLib and its attributes
- ★ List the ways to debug
- ★ Using PCDs to Configure DebugLib
- ★ Change Compiler & Linker Flags for debugging
- ★ Change the DebugLib instance to modify the debug output
- ★ Debug EDK II using VS Debugger - Demo

DEBUGGING OVERVIEW

Debug Methods

DEBUG and ASSERT macros in
EDK II code

DEBUG instead of Print functions

Software/hardware debuggers

Shell commands to test
capabilities for simple debugging



EDK II DebugLib Library

Debug and Assert macros in code

Enable/disable when compiled (target.txt)

Connects a Host to capture debug messages

DEBUGGING WITH PCDS

Using PCDs to Configure DebugLib

MdePkg Debug Library Class

```
[PcdsFixedAtBuild. PcdsPatchableInModule]
```

• • •

```
gEfiMdePkgTokenSpaceGuid.PcdDebugPropertyMask|0x1f
```

```
gEfiMdePkgTokenSpaceGuid.PcdDebugPrintErrorLevel|0x80000040
```

PCDs Set which drivers report errors and change
what messages get printed

PcdDebugPropertyMask Values

Debugging *Features* Enabled

```
#define DEBUG_PROPERTY_DEBUG_ASSERT_ENABLED      0x01
#define DEBUG_PROPERTY_DEBUG_PRINT_ENABLED      0x02
#define DEBUG_PROPERTY_DEBUG_CODE_ENABLED      0x04
#define DEBUG_PROPERTY_CLEAR_MEMORY_ENABLED      0x08
#define DEBUG_PROPERTY_ASSERT_BREAKPOINT_ENABLED 0x10
#define DEBUG_PROPERTY_ASSERT_DEADLOOP_ENABLED  0x20
```

Default value in OvmfPkg is 0x2f

Default value in EmulatorPkg is 0x1f

Determines which debugging features are enabled

PcdDebugPrintErrorLevel Values

Debug Messages Displayed

```
#define DEBUG_INIT      0x00000001 // Initialization
#define DEBUG_WARN      0x00000002 // Warnings
#define DEBUG_LOAD      0x00000004 // Load events
#define DEBUG_FS         0x00000008 // EFI File system
#define DEBUG_POOL       0x00000010 // Alloc & Free's Pool
#define DEBUG_PAGE       0x00000020 // Alloc & Free's Page
#define DEBUG_INFO       0x00000040 // Verbose
#define DEBUG_DISPATCH   0x00000080 // PEI/DXE Dispatchers
#define DEBUG_VARIABLE   0x00000100 // Variable
#define DEBUG_BM         0x00000400 // Boot Manager
#define DEBUG_BLKIO      0x00001000 // BlkIo Driver
#define DEBUG_NET        0x00004000 // SNP / Network Io Driver
#define DEBUG_UNDI       0x00010000 // UNDI Driver
#define DEBUG_LOADFILE   0x00020000 // Load File
#define DEBUG_EVENT      0x00080000 // Event messages
#define DEBUG_GCD        0x00100000 // Global Coherency Database changes
#define DEBUG_CACHE      0x00200000 // Memory range cache-ability changes
#define DEBUG_VERBOSE    0x00400000 // Detailed debug messages that may
                                // significantly impact boot performance
#define DEBUG_ERROR      0x80000000 // Error
```

Aliases EFI_D_INIT == DEBUG_INIT, etc..

Determines which messages we want to print

Changing PCD Values

Change all instances of a PCD in platform DSC

```
[PcdsFixedAtBuild.IA32]  
gEfiMdePkgTokenSpaceGuid.PcdDebugPrintErrorLevel|0x00000000
```

Change a single module's PCD values in DSC

```
MyPath/MyModule.inf {  
<PcdsFixedAtBuild>  
gEfiMdePkgTokenSpaceGuid.PcdDebugPrintErrorLevel|0x80000000  
}
```

Minimize message output and minimize size increase

Other Debug Related Libraries

ReportStatusCodeLib – Progress codes

`gEfiMdePkgTokenSpaceGuid.PcdReportStatusCodePropertyMask`

PostCodeLib – Enable Post codes

`gEfiMdePkgTokenSpaceGuid.PcdPostCodePropertyMask`

PerformanceLib – Enable Measurement

`gEfiMdePkgTokenSpaceGuid.PcdPerformanceLibraryPropertyMask`

Demo – Adding Debug Statements

Adding debug statements to the previous lab's SampleApp UEFI Shell application

Demo: Add debug statements to SampleApp

The following code was added after the “EFI_INPUT_KEY KEY;” statement: and before the first Print() statement as shown in the screen shot below:

```
DEBUG ((0xffffffff, "\n\nUEFI Base Training DEBUG DEMO\n") );
DEBUG ((0xffffffff, "0xffffffff USING DEBUG ALL Mask Bits Set\n") );

DEBUG ((DEBUG_INIT,      " 0x%08x USING DEBUG DEBUG_INIT\n", (UINTN)(DEBUG_INIT)) );
DEBUG ((DEBUG_WARN,      " 0x%08x USING DEBUG DEBUG_WARN\n", (UINTN)(DEBUG_WARN)) );
DEBUG ((DEBUG_LOAD,      " 0x%08x USING DEBUG DEBUG_LOAD\n", (UINTN)(DEBUG_LOAD)) );
DEBUG ((DEBUG_FS,        " 0x%08x USING DEBUG DEBUG_FS\n", (UINTN)(DEBUG_FS)) );
DEBUG ((DEBUG_POOL,      " 0x%08x USING DEBUG DEBUG_POOL\n", (UINTN)(DEBUG_POOL)) );
DEBUG ((DEBUG_PAGE,      " 0x%08x USING DEBUG DEBUG_PAGE\n", (UINTN)(DEBUG_PAGE)) );
DEBUG ((DEBUG_INFO,      " 0x%08x USING DEBUG DEBUG_INFO\n", (UINTN)(DEBUG_INFO)) );
DEBUG ((DEBUG_DISPATCH,  " 0x%08x USING DEBUG DEBUG_DISPATCH\n", (UINTN)(DEBUG_DISPATCH)));
DEBUG ((DEBUG_VARIABLE,  " 0x%08x USING DEBUG DEBUG_VARIABLE\n", (UINTN)(DEBUG_VARIABLE)));
DEBUG ((DEBUG_BM,        " 0x%08x USING DEBUG DEBUG_BM\n", (UINTN)(DEBUG_BM)) );
DEBUG ((DEBUG_BLKIO,     " 0x%08x USING DEBUG DEBUG_BLKIO\n", (UINTN)(DEBUG_BLKIO)) );
DEBUG ((DEBUG_NET,       " 0x%08x USING DEBUG DEBUG_NET\n", (UINTN)(DEBUG_NET)) );
DEBUG ((DEBUG_UNDI,      " 0x%08x USING DEBUG DEBUG_UNDI\n", (UINTN)(DEBUG_UNDI)) );
DEBUG ((DEBUG_LOADFILE,  " 0x%08x USING DEBUG DEBUG_LOADFILE\n", (UINTN)(DEBUG_LOADFILE)));
DEBUG ((DEBUG_EVENT,     " 0x%08x USING DEBUG DEBUG_EVENT\n", (UINTN)(DEBUG_EVENT)) );
DEBUG ((DEBUG_GCD,       " 0x%08x USING DEBUG DEBUG_GCD\n", (UINTN)(DEBUG_EVENT)) );
DEBUG ((DEBUG_CACHE,     " 0x%08x USING DEBUG DEBUG_CACHE\n", (UINTN)(DEBUG_CACHE)) );
DEBUG ((DEBUG_VERBOSE,   " 0x%08x USING DEBUG DEBUG_VERBOSE\n", (UINTN)(DEBUG_VERBOSE)) );
DEBUG ((DEBUG_ERROR,     " 0x%08x USING DEBUG DEBUG_ERROR\n", (UINTN)(DEBUG_ERROR)) );
```

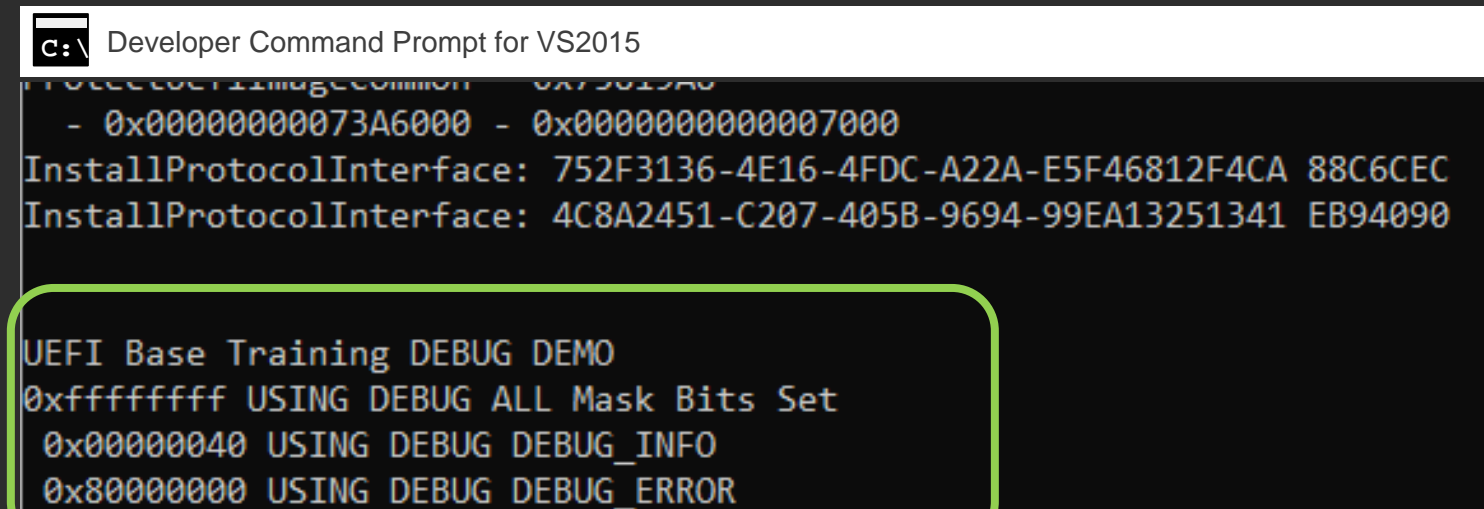
Demo: Run and Test Result

Run the application from the shell

```
Shell> SampleApp
```

Check the VS Debug output

Visual Studio command prompt window output



```
c:\> Developer Command Prompt for VS2015
UEFI Base Training DEBUG DEMO
0xffffffff USING DEBUG ALL Mask Bits Set
0x00000040 USING DEBUG DEBUG_INFO
0x80000000 USING DEBUG DEBUG_ERROR
```

Demo: Change PCDs for SampleApp

The following was added to EmulatorPkg.dsc

```
SampleApp/SampleApp.inf {  
  <PcdsFixedAtBuild>  
    gEfiMdePkgTokenSpaceGuid.PcdDebugPropertyMask|0xff  
    gEfiMdePkgTokenSpaceGuid.PcdDebugPrintErrorLevel|0xffffffff  
}
```


Demo: Build, Run and Test Result

Run the application from the shell

```
Shell> SampleApp
```

Check the VS Debug output

Visual Studio command prompt window output

```
C:\> Developer Command Prompt for VS2015
UEFI Base Training DEBUG DEMO
0xffffffff USING DEBUG ALL Mask Bits Set
0x00000001 USING DEBUG DEBUG_INIT
0x00000002 USING DEBUG DEBUG_WARN
0x00000004 USING DEBUG DEBUG_LOAD
0x00000008 USING DEBUG DEBUG_FS
0x00000010 USING DEBUG DEBUG_POOL
0x00000020 USING DEBUG DEBUG_PAGE
0x00000040 USING DEBUG DEBUG_INFO
0x00000080 USING DEBUG DEBUG_DISPATCH
0x00000100 USING DEBUG DEBUG_VARIABLE
0x00000400 USING DEBUG DEBUG_BM
0x00001000 USING DEBUG DEBUG_BLKIO
0x00004000 USING DEBUG DEBUG_NET
0x00010000 USING DEBUG DEBUG_UNDI
0x00020000 USING DEBUG DEBUG_LOADFILE
0x00080000 USING DEBUG DEBUG_EVENT
0x00080000 USING DEBUG DEBUG_GCD
0x00080000 USING DEBUG DEBUG_CACHE
0x00080000 USING DEBUG DEBUG_VERBOSE
0x80000000 USING DEBUG DEBUG_ERROR
```

CHANGING FLAGS

Changing Compiler & Linker Flags

Precedence for Debug Flags Hierarchy

DSC [BuildOptions] section
(platform scope)

INF [BuildOptions]
section

DSC <BuildOptions>
under a specific module

1. Tools_def.txt
2. DSC [BuildOptions] section (platform scope)
3. INF [BuildOptions] section (module scope)
4. DSC <BuildOptions> under a specific module

Example from Microsoft* compiler to turn off optimization

“/O2” to “/O1” requires “/Od /O1” flags

Change common flags in platform DSC

```
[BuildOptions]
DEBUG_*_IA32_CC_FLAGS = /Od /Oy-
```

Change a single module's flags in DSC

```
MyPath/MyModule.inf {
<BuildOptions>
    DEBUG_*_IA32_CC_FLAGS = /Od /Oy-
}
```

DebugLib USAGE

The DebugLib Class Interface

MdePkg\Include\Library\DebugLib.h

Macros

(where PCDs are checked)

```
ASSERT (Expression)  
DEBUG (Expression)  
ASSERT_EFI_ERROR (StatusParameter)  
ASSERT_PROTOCOL_ALREADY_INSTALLED(...)
```

Advanced Macros

```
DEBUG_CODE (Expression)  
DEBUG_CODE_BEGIN() & DEBUG_CODE_END()  
DEBUG_CLEAR_MEMORY(...)
```



DebugLib Instances (1)

Implementation

BaseDebugLibSerialPort

- Instance of DebugLib
- Uses SerialPortLib class to send debug output to serial port
- Default for many platforms: BaseDebugLibNull
- OVMF uses it with Switch DEBUG_ON_SERIAL_PORT



DebugLib Instances (2)

Implementation

UefiDebugLibConOut UefiDebugLibStdErr

- Instances of DebugLib (for apps and drivers)
- Send all debug output to console/debug console



DebugLib Instances (3)

Implementation

PeiDxeDebugLibReportStatusCode

- Sends ASCII String specified by Description Value to the ReportStatusCode()
- May also use the SerialPortLib class to send debug output to serial port
- BaseDebugLibNull - Resolves references

Default for most platforms



DebugLib Instances (4)

Implementation

BaseDebugLibNull

- Resolves references
- Return Success

Instance to use to disable Debug



Changing Library Instances

Change common library instances in the platform DSC by module type

```
[LibraryClasses.common.IA32]  
DebugLib|MdePkg/Library/BaseDebugLibNull/BaseDebugLibNull.inf
```

Change a single module's library instance in the platform DSC

```
MyPath/MyModule.inf {  
<LibraryClasses>  
DebugLib|MdePkg/Library/BaseDebugLibSerialPort.inf  
}
```

Demo – Library Instances for Debugging

Changing specific debug library instances.

Demo: Using Library Instances for Debugging

The following was added to EmulatorPkg.dsc changing the library instances

```
SampleApp/SampleApp.inf {  
  <LibraryClasses>  
    DebugLib|MdePkg/Library/UefiDebugLibConOut/UefiDebugLibConOut.inf  
}
```

Demo: Debug Output in the Console

Application from the shell

```
Shell> SampleApp
```

See that the output from the Debug statements now goes to the console

Debug output to console

```
Shell> sampleapp
```

```
UEFI Base Training DEBUG DEMO
0xffffffff USING DEBUG ALL Mask Bits Set
0x00000040 USING DEBUG DEBUG_INFO
0x80000000 USING DEBUG DEBUG_ERROR
System Table: 0xB7A7C018
```

```
Press any Key to continue :
```

EmulatorPkg

Demo: Debugging EDK II with VS Debugger

SampleApp.c has an
“ASSERT_EFI_ERROR” statement added

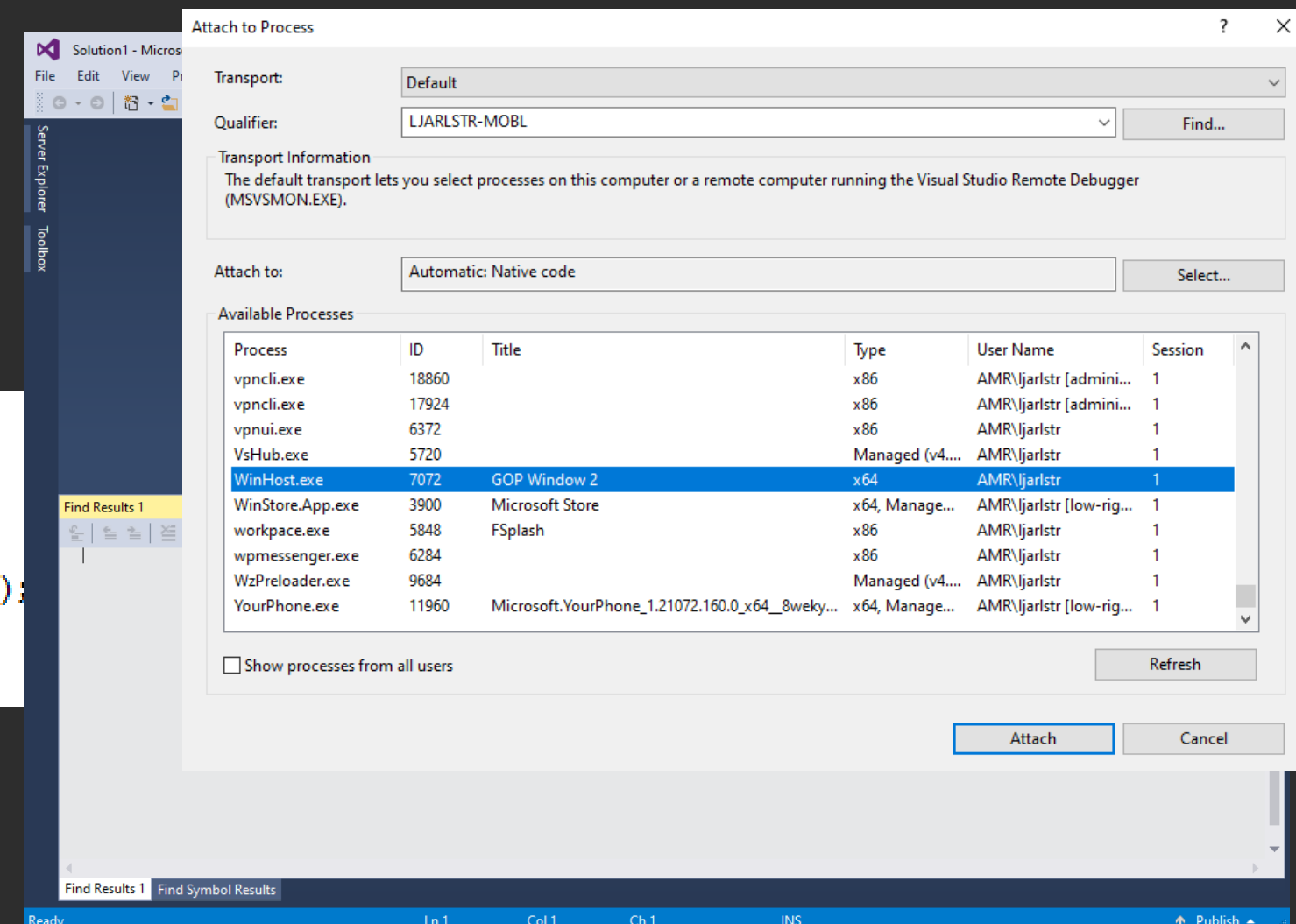
```
EFI_STATUS      Status;
Status = EFI_NO_RESPONSE;
...
ASSERT_EFI_ERROR(Status);
```

```
EFI_STATUS Status;
Status = EFI_NO_RESPONSE; // or any EFI Error
```

```
DEBUG((0xffffffff, "\n\nUEFI Base Training DEBUG DEMO\n"));
DEBUG((0xffffffff, "0xffffffff USING DEBUG ALL Mask Bits Set\n"));
```

```
ASSERT_EFI_ERROR(Status);
```

Visual Studio enable the WinHost for
Debugging



Demo: Debug with VS - ASSERT

Application from the shell

```
Shell> SampleApp
```

Assert in VS Command Prompt

Visual Studio command prompt window output

```
Developer Command Prompt for VS2015 - runEmulator.bat
InstallProtocolInterface: 5B1B31A1-9562-11D2-8E3F-00A0C969723B 1D55B83F440
LoadLibraryEx (
  c:\fw\edk2-ws\Build\EmulatorX64\DEBUG_VS2015x86\X64\SampleApp\SampleApp\DEBUG\SampleApp.DLL,
  NULL, DONT_RESOLVE_DLL_REFERENCES)
Loading driver at 0x1D55B7E4000 EntryPoint=0x00077441000 SampleApp.efi
InstallProtocolInterface: BC62157E-3E33-4FEC-9920-2D3B36D750DF 1D55B840018
ProtectUefiImageCommon - 0x5B83F440
- 0x0000001D55B7E4000 - 0x000000000000E000
InstallProtocolInterface: 752F3136-4E16-4FDC-A22A-E5F46812F4CA 1D557D8D628

UEFI Base Training DEBUG DEMO
0xFFFFFFFF USING DEBUG ALL Mask Bits Set

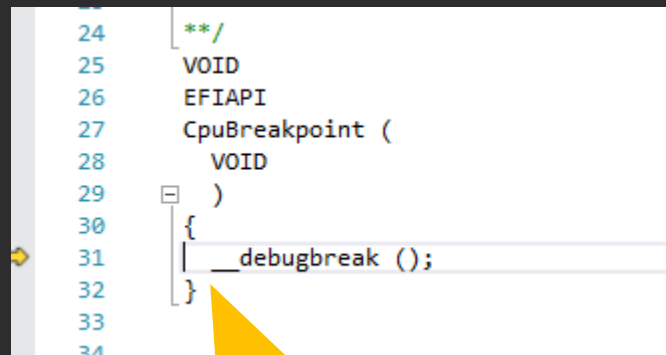
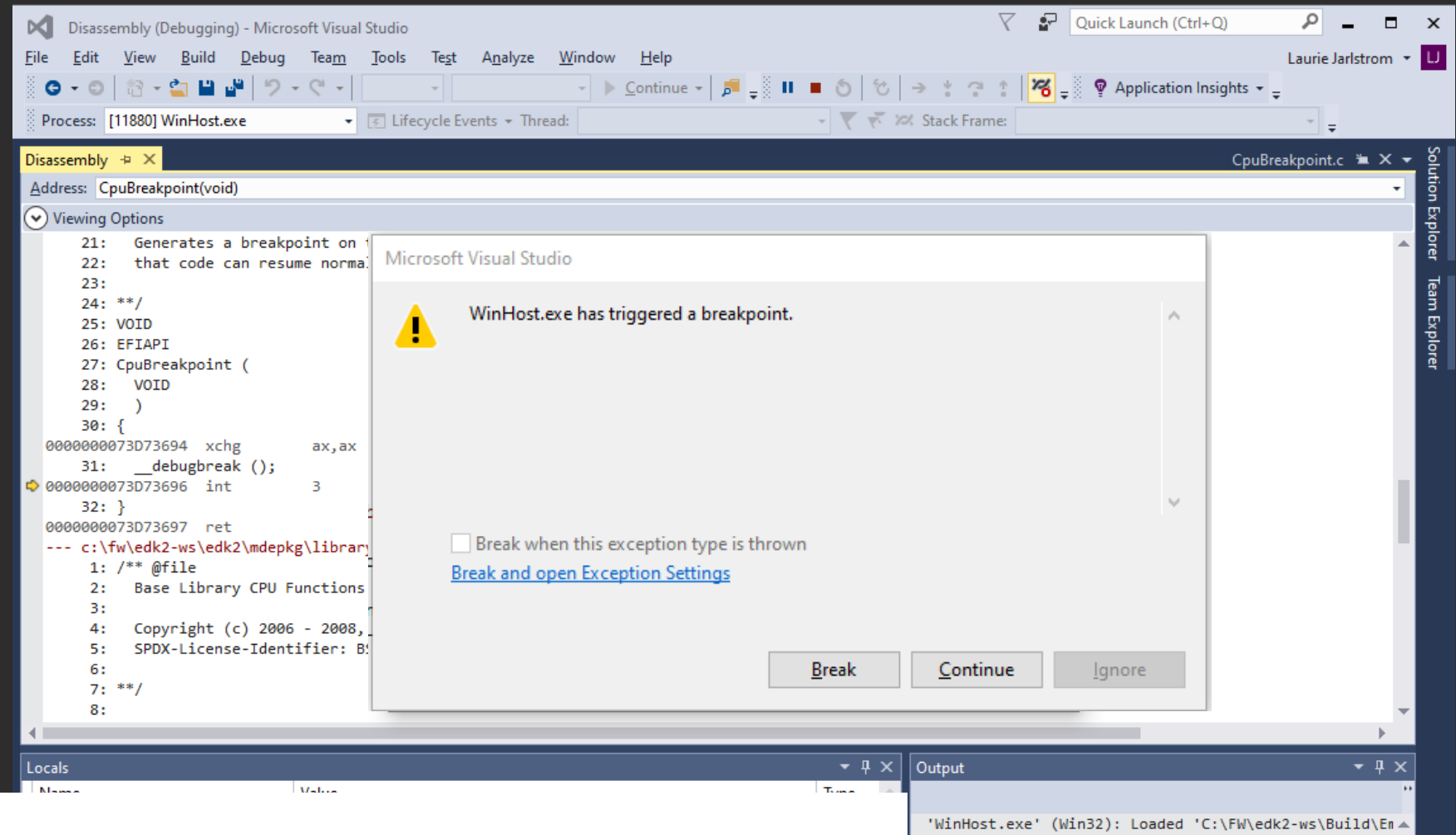
ASSERT_EFI_ERROR (Status = No Response)

DXE_ASSERT!: [SampleApp] c:\fw\edk2-ws\edk2\SampleApp\SampleApp.c (51): !EFI_ERROR (Status)
```

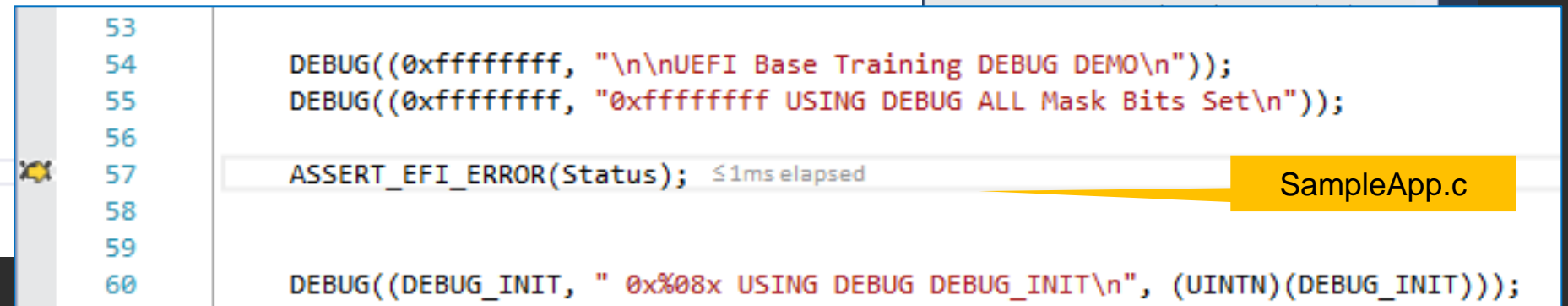
Lab 5: Debug with VS - ASSERT

Windows* VS Debugger

“F5” to continue
“Shift F5” to Stop
debugging



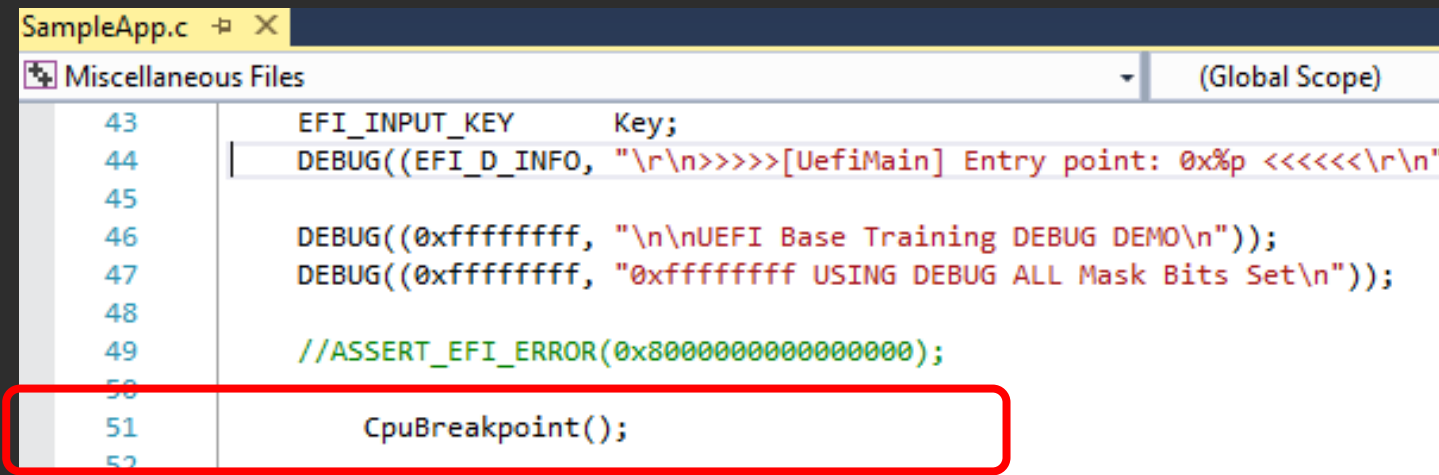
“F10” - Step over 2-3 times



Demo: Debug with VS - CpuBreakpoint

SampleApp.c with “CpuBreakpoint();” Statement and commented out the “ASSERT”

CpuBreakpoint();



The screenshot shows the Visual Studio code editor with the file 'SampleApp.c' open. The editor displays the following code:

```
43  EFI_INPUT_KEY    Key;  
44  DEBUG((EFI_D_INFO, "\r\n>>>>>[UefiMain] Entry point: 0x%p <<<<<\r\n"  
45  
46  DEBUG((0xffffffff, "\n\nUEFI Base Training DEBUG DEMO\n"));  
47  DEBUG((0xffffffff, "0xffffffff USING DEBUG ALL Mask Bits Set\n"));  
48  
49  //ASSERT_EFI_ERROR(0x8000000000000000);  
50  
51  CpuBreakpoint();  
52
```

The line 'CpuBreakpoint();' at line 51 is highlighted with a red rectangle. The 'Miscellaneous Files' pane on the left shows '(Global Scope)'.

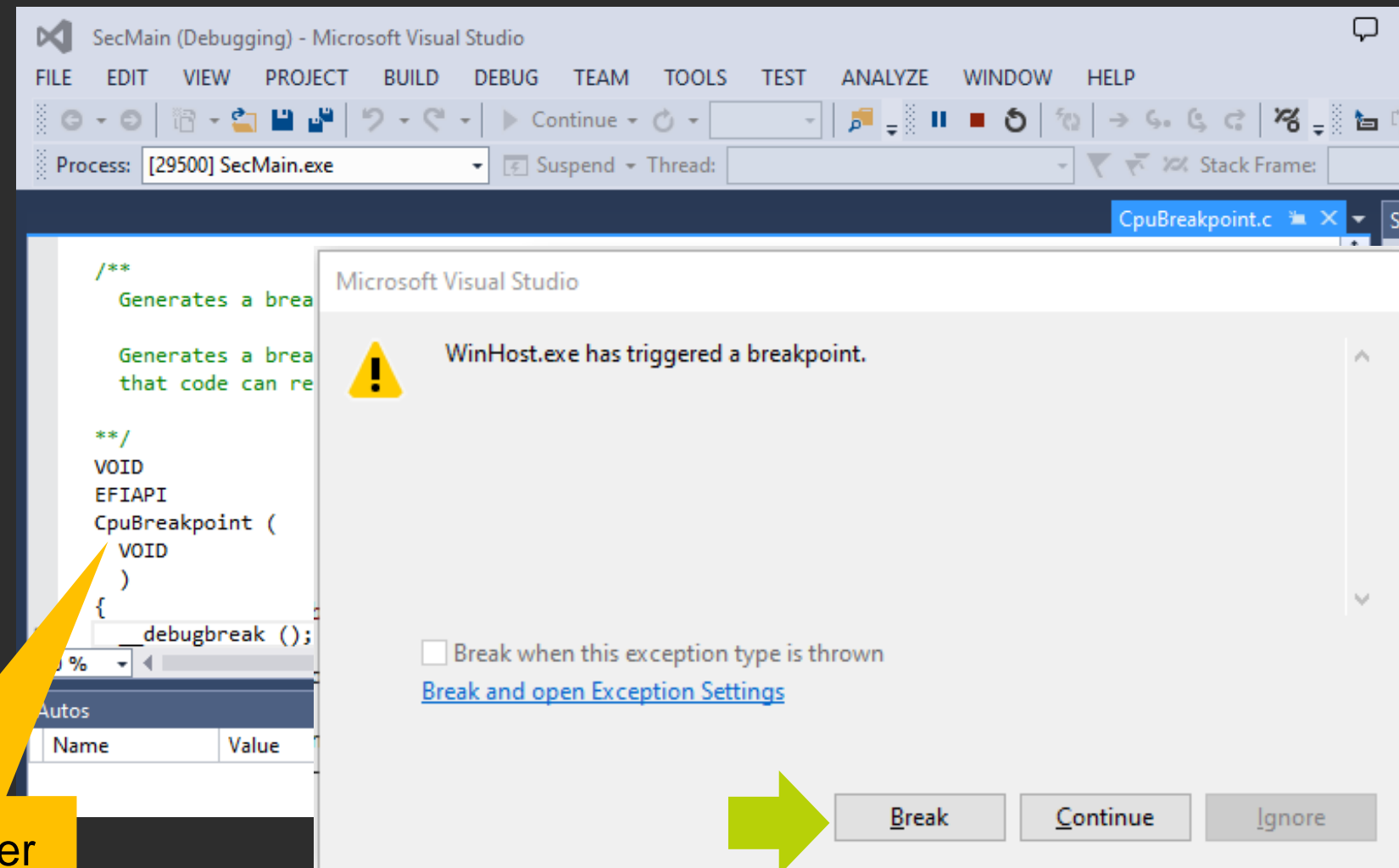
Demo: Debug with VS

Application from the shell

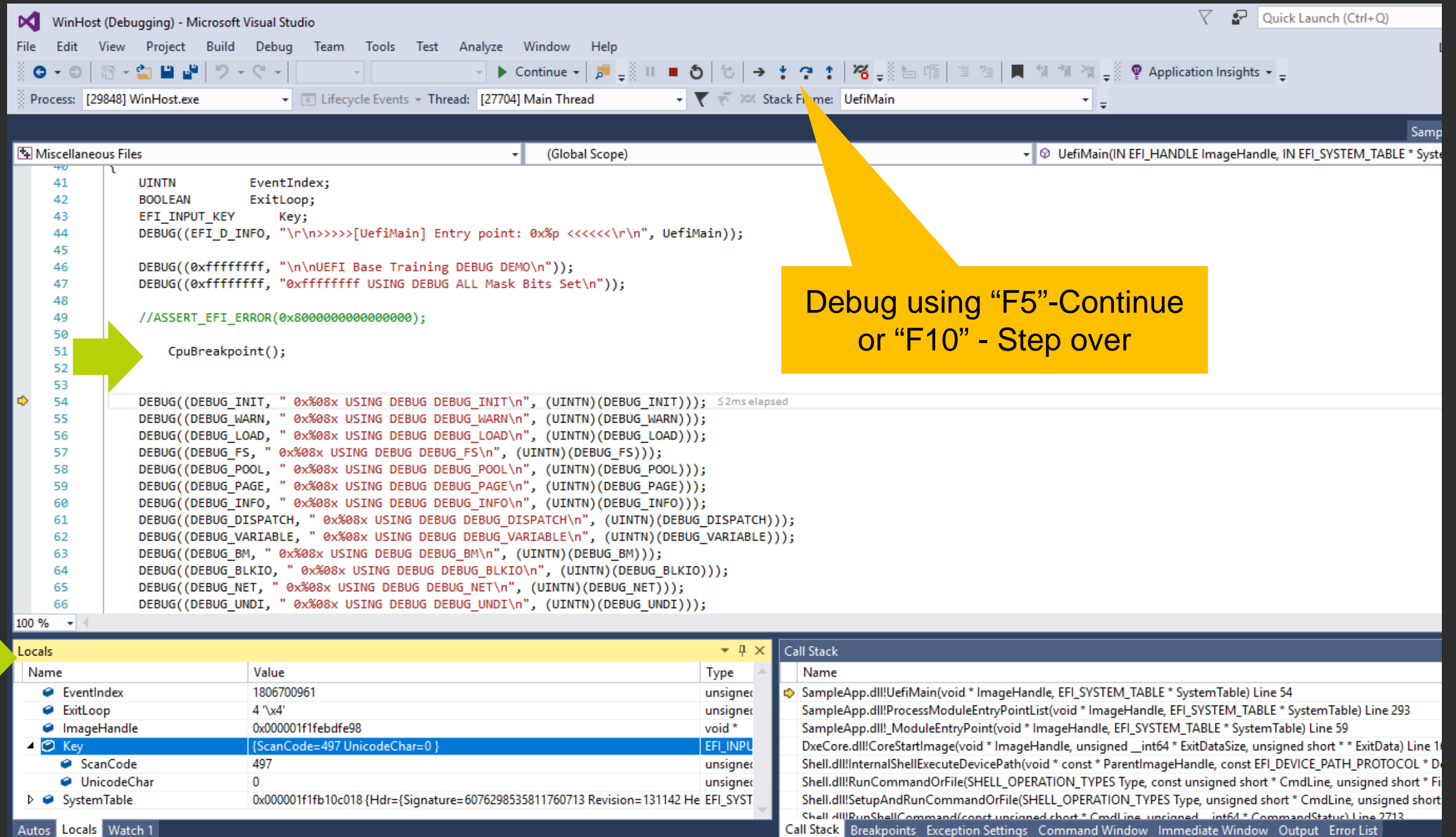
```
Shell> SampleApp
```

VS Debugger pop up,
Press “F10” until
SampleApp.c shows

“F10” - Step over



Demo Windows Visual Studio Debugger



WinHost (Debugging) - Microsoft Visual Studio

File Edit View Project Build Debug Team Tools Test Analyze Window Help

Process: [29848] WinHost.exe Lifecycle Events Thread: [27704] Main Thread Stack Frame: UefiMain

Miscellaneous Files (Global Scope) UefiMain(IN EFI_HANDLE ImageHandle, IN EFI_SYSTEM_TABLE * SystemTable)

```

41  UINTN      EventIndex;
42  BOOLEAN    ExitLoop;
43  EFI_INPUT_KEY  Key;
44  DEBUG((EFI_D_INFO, "\r\n>>>>[UefiMain] Entry point: 0x%p <<<<<\r\n", UefiMain));
45
46  DEBUG((0xffffffff, "\n\nUEFI Base Training DEBUG DEMO\n"));
47  DEBUG((0xffffffff, "0xffffffff USING DEBUG ALL Mask Bits Set\n"));
48
49  //ASSERT_EFI_ERROR(0x8000000000000000);
50
51  CpuBreakpoint();
52
53
54  DEBUG((DEBUG_INIT, " 0x%08x USING DEBUG DEBUG_INIT\n", (UINTN)(DEBUG_INIT)));
55  DEBUG((DEBUG_WARN, " 0x%08x USING DEBUG DEBUG_WARN\n", (UINTN)(DEBUG_WARN)));
56  DEBUG((DEBUG_LOAD, " 0x%08x USING DEBUG DEBUG_LOAD\n", (UINTN)(DEBUG_LOAD)));
57  DEBUG((DEBUG_FS, " 0x%08x USING DEBUG DEBUG_FS\n", (UINTN)(DEBUG_FS)));
58  DEBUG((DEBUG_POOL, " 0x%08x USING DEBUG DEBUG_POOL\n", (UINTN)(DEBUG_POOL)));
59  DEBUG((DEBUG_PAGE, " 0x%08x USING DEBUG DEBUG_PAGE\n", (UINTN)(DEBUG_PAGE)));
60  DEBUG((DEBUG_INFO, " 0x%08x USING DEBUG DEBUG_INFO\n", (UINTN)(DEBUG_INFO)));
61  DEBUG((DEBUG_DISPATCH, " 0x%08x USING DEBUG DEBUG_DISPATCH\n", (UINTN)(DEBUG_DISPATCH)));
62  DEBUG((DEBUG_VARIABLE, " 0x%08x USING DEBUG DEBUG_VARIABLE\n", (UINTN)(DEBUG_VARIABLE)));
63  DEBUG((DEBUG_BM, " 0x%08x USING DEBUG DEBUG_BM\n", (UINTN)(DEBUG_BM)));
64  DEBUG((DEBUG_BLKIO, " 0x%08x USING DEBUG DEBUG_BLKIO\n", (UINTN)(DEBUG_BLKIO)));
65  DEBUG((DEBUG_NET, " 0x%08x USING DEBUG DEBUG_NET\n", (UINTN)(DEBUG_NET)));
66  DEBUG((DEBUG_UNDI, " 0x%08x USING DEBUG DEBUG_UNDI\n", (UINTN)(DEBUG_UNDI)));

```

100 %

Locals

Name	Value	Type
EventIndex	1806700961	unsigned int
ExitLoop	4 '\x4'	unsigned char
ImageHandle	0x000001f1febdfe98	void *
Key	{ScanCode=497 UnicodeChar=0}	EFI_INPUT_KEY
ScanCode	497	unsigned short
UnicodeChar	0	unsigned char
SystemTable	0x000001f1fb10c018 {Hdr={Signature=6076298535811760713 Revision=131142 He EFI_SYST	EFI_SYSTEM_TABLE

Autos Locals Watch 1

Call Stack

Name
SampleApp.dll!UefiMain(void * ImageHandle, EFI_SYSTEM_TABLE * SystemTable) Line 54
SampleApp.dll!ProcessModuleEntryPointList(void * ImageHandle, EFI_SYSTEM_TABLE * SystemTable) Line 293
SampleApp.dll!ModuleEntryPoint(void * ImageHandle, EFI_SYSTEM_TABLE * SystemTable) Line 59
DxeCore.dll!CoreStartImage(void * ImageHandle, unsigned __int64 * ExitDataSize, unsigned short * ExitData) Line 14
Shell.dll!InternalShellExecuteDevicePath(void * const * ParentImageHandle, const EFI_DEVICE_PATH_PROTOCOL * DevicePath) Line 14
Shell.dll!RunCommandOrFile(SHELL_OPERATION_TYPES Type, const unsigned short * CmdLine, unsigned short * ExitData) Line 14
Shell.dll!SetupAndRunCommandOrFile(SHELL_OPERATION_TYPES Type, unsigned short * CmdLine, unsigned short * ExitData) Line 14
Shell.dll!RunShellCommand(const unsigned short * CmdLine, unsigned __int64 * CommandStatus) Line 2713

Call Stack Breakpoints Exception Settings Command Window Immediate Window Output Error List

Summary

- Define DebugLib and its attributes
- List the ways to debug
- Using PCDs to Configure DebugLib
- Change Compiler & Linker Flags for debugging
- Change the DebugLib instance to modify the debug output
- Debug EDK II using VS Debugger - Demo

Questions?



Return to Main Training Page



Return to Training Table of contents for next presentation [link](#)



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BACK UP

ISSUE:

Debugging in Emulator with Windows 7/10 and Visual Studio does not work?

Symptom: With Windows 7 a `CpuBreakpoint()` or `ASSERT` just exits with an error from the “Build Run” command.

Link to fix this issue:

https://github.com/tianocore/tianocore.github.io/wiki/NT32#Debugging_in_Nt32_Emulation_with_Windows_7_and_Visual_Studio_does_not_work

1. Run the RegEdt32
2. Navigate to the HKEY_LOCAL_MACHINE\SOFTWARE\Wow6432Node\Microsoft\Windows NT\CurrentVersion\AeDebug
3. Add a string value entry called "Auto" with a value of "1"

Windows 10 Visual Studio may not have this issue