Intel® UEFI Development Kit Debugger Tool (version 1.5) Configuration and Setup Guide

Version 1.11

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1.1 Document Purpose and Organization

This guide explains how to configure a host and target system and perform basic debugging operations from Windows platform and Linux platform host systems using the Intel® UEFI Development Kit Debugger Tool (Intel® UDK Debugger Tool). It also includes debugging tips and techniques as well as known issues, and it is intended for developers with a solid understanding of the Intel® UEFI Development Kit 2010 (Intel® UDK2010), and its predecessors and related subjects.

1.1.1 Configuration and Build

Chapters 1 and 2 provide an overview of the configuration and building of the firmware image.

1.1.2 Windows

Windows users should continue with Chapters 3, 4, 5.These chapters detail setting up the environment, usage, and known limitations of the Intel® UDK Debugger Tool for Windows platforms.

1.1.3 Linux

After Chapter 2, Linux users should skip to Chapters 6, 7, 8. These chapters detail setting up the environment, usage, and known limitations of the Intel® UDK Debugger Tool for Linux platforms.

1.1.4 Debugging Tips and Appendix

Chapter 9 provides general debugging tips, and the Appendix provides additional information, such as a glossary and document conventions.

1.2 Tool Introduction

The Intel® UEFI Development Kit Debugger Tool (Intel® UDK Debugger Tool) helps debug UDK-compliant applications, drivers and firmware (hereafter called “firmware”) on Intel® IA-32 and x64 Architecture platforms. The debug solution is a combination of the Intel® UDK Debugger Tool and an OS-specific debugger on the host machine along with a source-level debug package (provided by Intel) on the target machine.

The Intel® UDK Debugger Tool adds functionality to the OS-specific debugger for software debugging firmware. For Microsoft Windows platforms, the Intel® UDK Debugger Tool adds functionality to the Microsoft Windows Debug Tool* (WinDbg). On a Linux platform, the tool adds functionality to the GNU Project Debugger* (GDB).

This overview section includes these main discussions:

- Configuration of host and target systems
- OVMF platform used to demonstrate debug process

1.3 Configuration

The debug environment consists of:

Debug solution:

Intel® UDK Debugger Tool, OS-specific debugger tool, and a source-level debugger package.

Host machine:

Configured with the Intel® UDK Debugger Tool and the appropriate OS-specific debugger: WinDbg or GDB. The Intel® UDK Debugger Tool includes extension commands for OS-specific debuggers.

Target machine:

Includes the UDK firmware to be debugged. The firmware image must be built with the source-level debug package (SourceLevelDebugPkg) provided by Intel.

Debug cable:

Null modem cable or USB 2.0 or 3.0 debug cable.

1.3.1 Supported platforms

The Intel® UDK Debugger Tool supports these platforms:

Microsoft Windows platforms:

- Windows 7* x64
- Windows 8* x64

Linux platforms:

- Ubuntu* 14.04.1 LTS IA32 and x64 client

The Intel® UDK Debugger Tool may work on additional Linux platforms. However, the Intel® UDK Debugger Tool has not yet been fully validated for additional Linux platforms.

1.3.2 Host and target configurations

Requirements for the host machine debug configuration are OS-specific. The target machine debug configuration is the same for both Windows and Linux platforms.

The following figure shows the host and target machines.

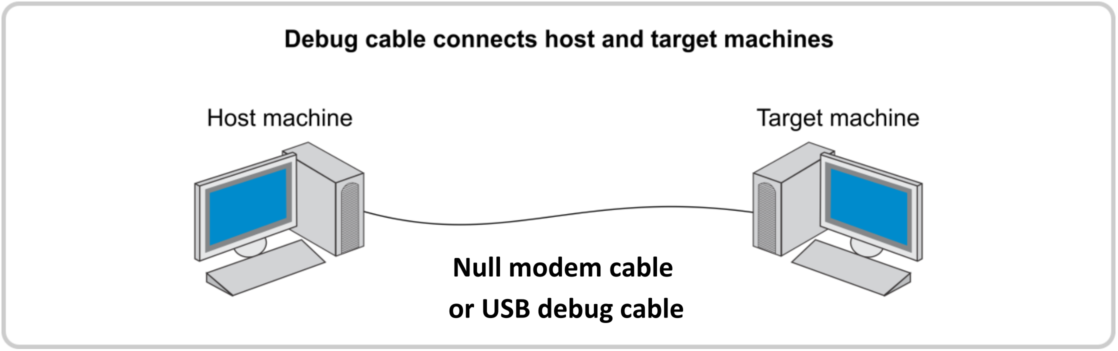


Figure 1 Cable connection between the target and host machine

The next two sections list the specific configuration requirements for Windows and Linux platforms.

1.3.2.1 Host configuration for Windows platforms

This user manual assumes you have a working knowledge of the Intel® UEFI Development Kit 2010 (Intel® UDK2010) and the Microsoft Windows Debug Tool* (WinDbg).

Using the Intel® UDK Debugger Tool on a Windows platform requires a host machine configured with:

- Microsoft Win7* x64 or Win8* x64
- Microsoft Windows Debug Tool* (WinDbg) 6.11.0001.404 X86.
- Intel® UDK Debugger Tool, which adds functionality to WinDbg, is available for download at: www.intel.com/udk.

1.3.2.2 Host configuration for Linux platforms

This user manual assumes you have a working knowledge of the Intel® UEFI Development Kit 2010 (Intel® UDK2010) and the GNU Project Debugger* (GDB) for Linux platforms.

Using the Intel® UDK Debugger Tool on a Linux platform requires a host machine configured with:

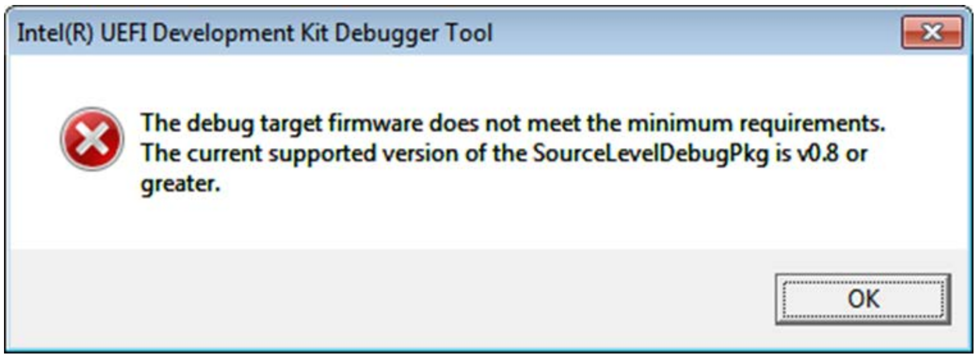
- A supported Linux operating system:
  - Ubuntu* 14.04.1 LTS IA32 and x64 client
- GNU Debugger* (GDB)
- Intel® UDK Debugger Tool, which adds functionality to GDB. It is available at www.intel.com/udk.

1.3.3 Target configuration

The target machine must have a firmware build that includes the source-level debug package SourceLevelDebugPkg—a part of the Intel® UEFI Development Kit 2010 (Intel® UDK2010), located at www.tianocore.org.

When the Intel® UDK Debugger Tool connects to the TARGET firmware with an older version of SourceLevelDebugPkg code:

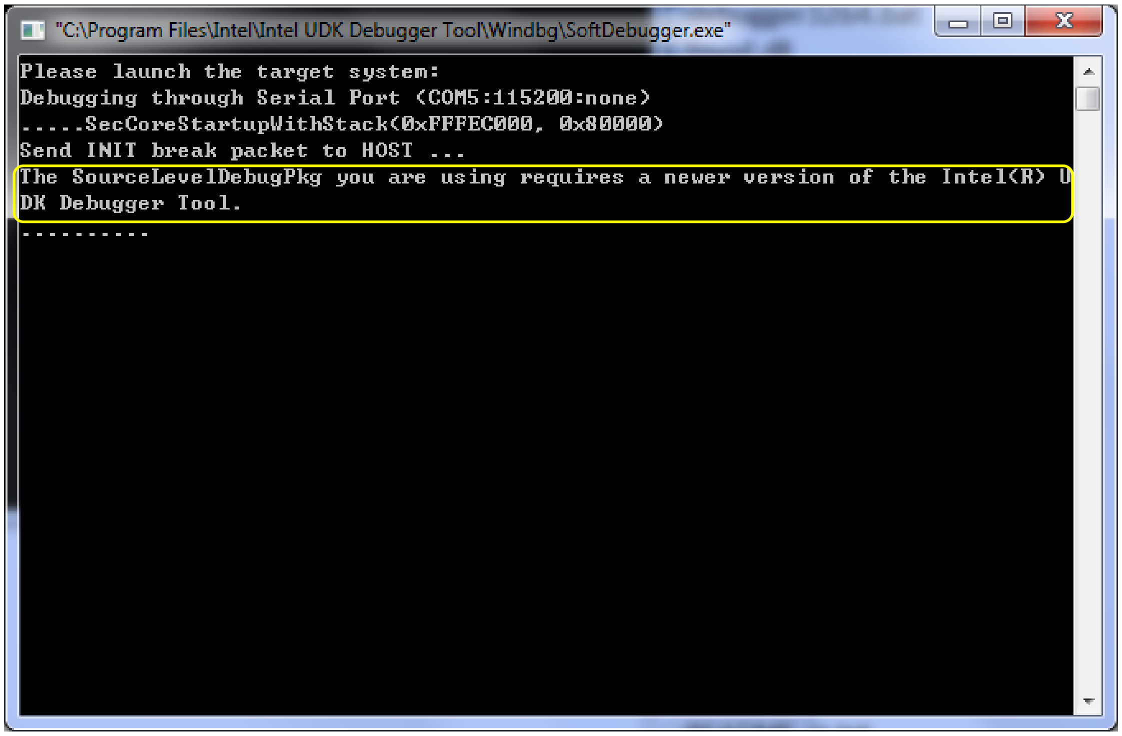
- An error message is displayed advising that the TARGET code must be upgraded.
- The debug session is terminated.
- You should update TARGET firmware to use the latest SourceLevelDebugPkg.



The debug target firmware does not meet the minimum requirements. The current supported version of the SourceLevelDebugPkg is v0.8 or greater.

Figure 2 Current Tool to outdated TARGET connection advisory

Similarly, when an older version of the Intel® UDK Debugger Tool connects to firmware with a current version of TARGET, an upgrade advisory is issued.


"C:\Program Files\Intel\Intel UDK Debugger Tool\Windbg\SoftDebugger.exe"

```
Please launch the target system:
Debugging through Serial Port (COM5:115200:none)
.....SecCoreStartupWithStack(0xFFFEC000, 0x80000)
Send INIT break packet to HOST ...
The SourceLevelDebugPkg you are using requires a newer version of the Intel(R) U
DK Debugger Tool.
..........
```

Figure 3 Current TARGET to outdated Tool connection advisory

The Intel® UDK Debugger Tool for Windows version 1.2 hides the above debug console window resulting in the above upgrade advisory cannot be seen when that version of tool connects to a newer TARGET. To show the debug console, modify the configuration file with the following code snippet:

```
[Debug]
Debug=1
```

1.3.4 Connection between host and target machines

The Intel® UDK Debugger Tool supports the following interconnects:

- Null modem cable
- USB 2.0 or 3.0 debug cable
-
- Pipe
- TCP

1.4 OVMF platform and the debug process

The OVMF (Open-source Virtual Machine Firmware) platform implementation is used to demonstrate the debug process in some of the examples. The OVMF platform works on a virtual machine and can also be chosen as a configuration option in order to use virtual COM-to-COM connections.

The OVMF platform implementation is available from the EDK II project directory at www.tianocore.org (http://tianocore.sourceforge.net).

For general instructions on building and booting an OVMF image, including setting up COM connections, refer to the OVMF wiki page at

https://github.com/tianocore/tianocore.github.io/wiki/OVMF%20FAQ

2 Build the Firmware Image

2.1 Introduction

The firmware image, including the source-level debug package provided by Intel, must be built before using the Intel® UDK Debugger Tool. To do this, complete the appropriate build instructions for your Intel® UDK2010 platform, taking into consideration the modifications described in this section. The firmware build process and most of the considerations for building the image are the same for both Windows and Linux platforms. Differences are noted where appropriate.

2.1.1 Linux Platforms

For Linux platforms, x64 code can only be debugged when using GDB on x64 Linux platforms. Make sure the firmware image is built on an x64 Linux machine so that the debug symbols are accessible to the GDB.

2.1.2 Windows Platforms

For Windows platforms, there are two special considerations to keep in mind: aggressive zeroing and using the PE image format instead of TE. These considerations are discussed in section 2.2.5.

2.2 Modify the configuration files for the firmware used by the target machine

For best results, configure the firmware in the TARGET machine to support debugging.

- The firmware in the target machine must include the Intel provided source-level debug package because it supports debugging with the Intel® UDK Debugger Tool.
- Update the platform's DSC/FDF (firmware device file) files to ensure the appropriate library instances are selected. DSC files contain information used during the FDF build process.
- The serial port or USB debug port may need to be configured for debugging.

- When making changes to DSC/FDF files, define a macro that allows for conditional turn-on of the debug feature. An example is shown later in this section.

2.2.1 Select the appropriate libraries

When building the firmware, the DSC file must include the appropriate libraries in order to use the Intel® UDK Debugger Tool. Be sure to specify instances of each of the following:

- Debug Agent library
- Debug Communication library
- PeCoffExtraAction library

2.2.1.1 Specify the appropriate Debug Agent library

Different Debug Agent library instances provide the functions needed by the Intel® UDK Debugger Tool for modules executed in different booting phases. Be sure to specify the correct library instance in the DSC file.

The following table lists the correct library instances to replace the NULL instances for each module type. Intel® UDK Debugger Tool supports three scenarios: debugging from SEC, PEI or DXE.

2.2.1.1.1 Debugging from SEC (including PEI, DXE and SMM)

Table 1 Library instances by module type

Module type*	Library instance
SEC or PEI modules	SourceLevelDebugPkg/Library/DebugAgent/SecPeiDebugAgentLib.inf
DxeCore and DXE modules	SourceLevelDebugPkg/Library/DebugAgent/DxeDebugAgentLib.inf
SMM modules	SourceLevelDebugPkg/Library/DebugAgent/SmmDebugAgentLib.inf

** For definitions of acronyms, refer to Appendix A at the end of this user manual.*

2.2.1.1.2 Debugging from PEI (including DXE and SMM)

First, the PEIM SourceLevelDebugPkg/DebugAgentPei/DebugAgentPei.inf should be added into DSC/FDF files to enable source level debugging feature in PEI phase.

Only the PEIM dispatched after DebugAgentPei could be debugged.

Table 2 Library instances by module type

Module type	Library instance
SEC	MdeModulePkg/Library/DebugAgentLibNull/DebugAgentLibNull.inf

PEI modules	SourceLevelDebugPkg/Library/DebugAgent/SecPeiDebugAgentLib.inf
DxeCore and DXE modules	SourceLevelDebugPkg/Library/DebugAgent/DxeDebugAgentLib.inf
SMM modules	SourceLevelDebugPkg/Library/DebugAgent/SmmDebugAgentLib.inf

2.2.1.1.3 Debugging from DXE(including SMM)

Table 3 Library instances by module type

Module type	Library instance
SEC or PEI modules	MdeModulePkg/Library/DebugAgentLibNull/DebugAgentLibNull.inf
DxeCore and DXE modules	SourceLevelDebugPkg/Library/DebugAgent/DxeDebugAgentLib.inf
SMM modules	SourceLevelDebugPkg/Library/DebugAgent/SmmDebugAgentLib.inf

2.2.1.2 Specify the appropriate Debug Communication library

The non-null Debug Agent library instances consume the Debug Communication library. Because of this, the appropriate library instance for the type of communication cable (null modem or USB) used to connect the target and host systems must be specified (see the following table).

Table 4 Library instances by cable connection

Connection type	Library instance
Serial connection	SourceLevelDebugPkg/Library/DebugCommunicationLibSerialPort/DebugCommunicationLibSerialPort.inf This library instance depends on the Serial Port Library so an appropriate Serial Port Library instance must also be specified.
USB 2.0 debug cable connection	SourceLevelDebugPkg/Library/DebugCommunicationLibUsb/DebugCommunicationLibUsb.inf
USB 3.0 debug cable connection	PEIM: SourceLevelDebugPkg/Library/DebugCommunicationLibUsb3/DebugCommunicationLibUsb3Pei.inf DxeCore and DXE modules: SourceLevelDebugPkg/Library/DebugCommunicationLibUsb3/DebugCommunicationLibUsb3Dxe.inf

2.2.1.3 Specify the appropriate PeCoffExtraAction library

The PeCoffExtraAction library instance is invoked each time a module is loaded or unloaded. This library instance is responsible for informing the host that the target has loaded or unloaded a module. In the DSC file, the following PeCoffExtraAction library instance must be specified for any module that depends on the PeCoffExtraAction library class.

- SourceLevelDebugPkg/Library/PeCoffExtraActionLibDebug/PeCoffExtraAction LibDebug.inf

2.2.2 Turn debugging on or off

Use a macro to turn the debug feature on or off. The next two code samples show fragments in the LibraryClasses section that use a macro to do so.

```
[LibraryClasses]
!ifdef $(SOURCE_DEBUG_ENABLE)
PeCoffExtraActionLib|SourceLevelDebugPkg/Library/PeCoffExtraAct
ionLibDebug/PeCoffExtraActionLibDebug.inf
DebugCommunicationLib|SourceLevelDebugPkg/Library/DebugCommunic
ationLibSerialPort/DebugCommunicationLibSerialPort.inf

DebugAgentLib|SourceLevelDebugPkg/Library/DebugAgent/SecPeiDebu
gAgentLib.inf
!else
PeCoffExtraActionLib|MdePkg/Library/BasePeCoffExtraActionLibNul
l/BasePeCoffExtraActionLibNull.inf
DebugAgentLib|MdeModulePkg/Library/DebugAgentLibNull/DebugAgent
LibNull.inf
!endif
```

Figure 4 Example macro using a null modem cable

```
 [LibraryClasses]
!ifdef $(SOURCE_DEBUG_ENABLE)
PeCoffExtraActionLib|SourceLevelDebugPkg/Library/PeCoffExtraAct
ionLibDebug/PeCoffExtraActionLibDebug.inf
DebugCommunicationLib|SourceLevelDebugPkg/Library/DebugCommunic
ationLibUsb/DebugCommunicationLibUsb.inf
DebugAgentLib|SourceLevelDebugPkg/Library/DebugAgent/SecPeiDebu
gAgentLib.inf
!else
PeCoffExtraActionLib|MdePkg/Library/BasePeCoffExtraActionLibNul
l/BasePeCoffExtraActionLibNull.inf
DebugAgentLib|MdeModulePkg/Library/DebugAgentLibNull/DebugAgent
LibNull.inf
!endif
```

Figure 5 Example macro using a USB 2.0 debug cable

2.2.3 Configure a serial port for debug usage

The DebugCommunicationLibSerialPort library instance consumes the Serial Port Library.

In addition to choosing an appropriate Serial Port Library for the target platform, the serial port parameters on the target machine must be configured to match the settings on the host.

2.2.3.1 Baud rate

In most cases, it is preferable to set the baud rate to 115200.The baud rate should be the same on both the host and target machines.

If flow control is disabled and the serial connection is not stable, specify a lower baud rate.

2.2.3.2 Hardware flow control

On both Windows and Linux platforms, flow control is on by default. In most cases, make sure to not disable flow control.

If the platform-specific Serial Port Library does not support hardware flow control, flow control on the host machine should be turned off as well.

The flow control setting should be the same on both the host and target machines.

2.2.3.3 Configure the hardware buffer for FIFO

In order for the debug solution to work properly, the hardware buffer must be configured for first-in–first-out (FIFO). However, some platform-specific Serial Port Library instances may not enable receive and transmit for the FIFO hardware buffer.

The specific process for configuring the hardware buffer is hardware-dependent. Refer to your hardware's data sheet for information about the hardware buffer. The SerialPortLib instance provided by Intel in MdeModulePkg/Library/BaseSerialPortLib16550 library is also an example of implementing a FIFO hardware buffer.

2.2.3.4 Deactivate the terminal support

Because the IsaSerialDxe driver tries to manage the serial port, there is a conflict between IsaSerialDxe driver and DebugAgent using serial connection. One way to prevent the conflict is to remove the IsaSerialDxe module from the platform firmware device file (FDF). For example:

```
[FV.DXEFV]
...
!ifndef $(SOURCE_DEBUG_ENABLE)
INF
IntelFrameworkModulePkg/Bus/Isa/IsaSerialDxe/IsaSerialDxe.inf
!endif
...
```

Figure 6 Remove the IsaSerialDxe module from the FDF

The console device created by debug agent isn't added to the console input/output device list by default. There are two ways to add it to the list:

- change the setting through the Intel® UEFI Development Kit 2010 (Intel® UDK2010) front page UI
- change the platform boot manager library implementation.

The first method doesn't require rewriting code, but the setting needs to be manually changed every time the firmware is burned.

The console device path begins with a vendor defined device path node followed by a UART device path node and a vendor defined messaging device path node. An example follows:

- VenHw(865A5A9B-B85D-474C-8455-65D1BE844BE2)/Uart(115200,8,N,1)/VenPcAnsi()

Refer to the global variable, mSerialIoDevicePath, in the SourceLevelDebugPkg/Library/DebugAgent/DxeDebugAgent/SerialIo.c file for console device path details.

If the platform has multiple serial ports and those ports, other than the debug port, are needed as console devices as well, do not remove the IsaSerialDxe module from the FDF because the IsaSerialDxe module manages those other serial ports.

Instead, modify the module that produces the IsaAcpi protocol to *not* produce the IsaAcpi protocol for the debug port.

For the OVMF platform, modify the PCD in the DSC file instead of the IsaAcpiDxe module.

```
!if $(SOURCE_DEBUG_ENABLE) == TRUE
  gPcAtChipsetPkgTokenSpaceGuid.PcdIsaAcpiCom1Enable|FALSE
!else
  gPcAtChipsetPkgTokenSpaceGuid.PcdIsaAcpiCom1Enable|TRUE
!endif
```

Figure 7 Don't produce IsaAcpi protocol for debug port

2.2.4 Configure the USB 2.0 debug port

2.2.4.1 Configure PCDs

The DebugCommunicationLibUsb library instance requires that several PCDs (platform configuration database) be configured correctly. The default value provided by the SourceLevelDebugPkg works for most cases, but the values may need to be adjusted.

For example, two PCDs for a WinDbg-based debug solution follow:

- gEfiSourceLevelDebugPkgTokenSpaceGuid.PcdUsbDebugPortMemorySpaceBase
- gEfiSourceLevelDebugPkgTokenSpaceGuid.PcdUsbEhciMemorySpaceBase

The example PCDs specify the base address for the memory-mapped IO (base address register) for the extensible host controller interface (EHCI) controller and the USB debug port since the debug agent may run early in SEC.

CAUTION: Make sure these memory ranges do not conflict with memory ranges (including physical memory) assigned to other devices. Memory conflicts can cause the debugger to fail.

The following example PCD specifies the PCI (Peripheral Component Interconnect) address of the EHCI controller.

- gEfiSourceLevelDebugPkgTokenSpaceGuid.PcdUsbEhciPciAddress

The EHCI includes the debug port to be used for debug. The PCI address is specified by bus, device, and function number. The bit layout for the PCD is shown in Table 5.

Table 5 Bit layout for an example PCD

Bits 28~31	Bits 20~27	Bits 15~19	Bits 12~14	Bits 00~11
0	Bus number	Device number	Function number	0

For example, for a PCI address at bus 0x0, device 0x1D, function 0x07, the PCD value is 0x000EF000.

2.2.4.2 Identify the correct USB port for the debug cable

There is only one USB port in one EHCI controller that supports debugging and some motherboards may not wire this port to a physical USB port. It may be difficult to discover the correct USB port for the USB debug cable.

If a valid USB debug port can't be located, a USB debug cable cannot be used to establish a debug communication channel.

A few ways to identify the correct port follow.

- Read the EHCI controller datasheet and identify the port number supporting USB de-bug. The port number should be listed at bits 20~23 of the EHCI HCSPARAMS register.
- Plug the USB debug cable into one of the USB ports on the target system and boot to the UEFI shell.
  - Identify the device path of the USB debug cable and make sure the cable is plugged into the USB port supporting debug.
  - If not seen, plug the USB debug cable into another USB port and view the device path again.
- Plug the USB debug cable into one of the USB ports on the target system.
  - Boot to Windows and launch the Microsoft UsbView* tool (usbview.exe) included with the Microsoft Windows Debugging Tools*.
- Look at the USB device tree structure then identify the port number for the parent node of the USB debug cable device. Count the ports from top to bottom in the list.
  - If the port number listed is not the one that supports USB debugging, plug the USB debug cable into another USB port until a match is found.

2.2.4.3 Identify the correct USB connection orientation

The Ajays USB 2.0 debug cable is a device used to connect HOST and TARGET machines for source-level debugging. From the device's appearance, it's hard to distinguish which end to connect to the Host and which to the Target. This is important, however, because the connection orientation determines which end provides the power to the debug cable and, therefore, impacts the debug cable's behavior.

The debug cable *must* be powered by the TARGET.

- To confirm proper orientation, connect one end of the device to the HOST.
  - If oriented and connected properly, the Windows Device Manager should NOT detect it.
  - If it *is* detected by the device manager, connect the opposite end of the debug cable to the HOST.

- Connect the open end to the Target.
  - When powered-on, the Windows Device Manager at the Host side should find the USB debug cable attached.
  - Note that if the connection is not made in this recommended fashion, it may be not stable.

Figure 8 Ajays USB 2.0 debug cable

2.2.5 Additional configuration requirements

This discussion includes three special considerations:

- *Windows and Linux:* Disabling compiler optimization in order to include more debug information in the compiler's output file
- *Windows:* Turning off aggressive zeroing
- *Windows**:*** Using the PE (PE/COFF execution) image format instead of TE

2.2.5.1 Include more debug information in the compiler's output

Compiler optimization can reduce the amount of debug information included in the output file. However, compiler options for particular modules can be added in the Components section of the DSC file to force the compiler to include more debug information in the output file.

For example, with *Windows*, the default /O2 (level 2 optimization) switch turns on some optimization, reduces the size of the output file and omits some source level debugging information.

To disable level 2 optimization on a *Windows* system, use the /Od switch. To disable optimization on a *Linux* system, use the /O0 switch. In the following example, the /Od and /O0 switches prevent each OS-specific compiler from performing optimization functions.

```
[Components.IA32]
 ...
 MdeModulePkg/Core/Dxe/DxeMain.inf {
  ...
  <BuildOptions>
   MSFT:*_*_*_CC_FLAGS = /Od /Oy-
   GCC:*_*_*_CC_FLAGS = /O0
  ...
 }
```

Figure 9 Include more debug information in the compiler's output

2.2.5.2 WinDbg: Turning off aggressive zeroing

By default, the GenFw tool turns on "aggressive zeroing" for some sections in the PE/COFF (Portable ExeCutable and Object File Format) image.

However, these sections in the PE/COFF image may contain information needed for the debugger, e.g., the stack frame information. In order for the stack frame analysis to work effectively with the debugger, add the following lines to the platform DSC Build Options section:

```
!ifdef $(SOURCE_DEBUG_ENABLE)
 *_*_*_GENFW_FLAGS = --keepexceptiontable
!endif
```

2.2.5.3 WinDbg: Use the PE image format instead of TE

If frequent debug function calls between modules are needed when using WinDbg, use the PE image format instead of the terse execution (TE) image format.

When specifying the PE image format during build, note that the rule section of the code should also be changed as needed.

On Linux systems, GDB can handle both PE and TE image formats.

When using WinDbg, the rule section for PEIM (pre-EFI initialization module) must change as shown in the following examples.

Change from:

```
[Rule.Common.PEIM]
 FILE PEIM = $(NAMED_GUID)        {
   PEI_DEPEX PEI_DEPEX Optional
$(INF_OUTPUT)/$(MODULE_NAME).depex
   TE    TE           $(INF_OUTPUT)/$(MODULE_NAME).efi
   UI    STRING="$(MODULE_NAME)" Optional
   VERSION  STRING="$(INF_VERSION)" Optional
BUILD_NUM=$(BUILD_NUMBER)
 }
```

Figure 10 PEIM original

To:

```
[Rule.Common.PEIM]
 FILE PEIM = $(NAMED_GUID) {
   PEI_DEPEX PEI_DEPEX Optional   |.depex
   PE32   PE32 Align = 32     |.efi
   UI    STRING="$(MODULE_NAME)" Optional
   VERSION  STRING="$(INF_VERSION)" Optional
BUILD_NUM=$(BUILD_NUMBER)
 }
```

Figure 11 Revised rule change for PEIM

Apply similar changes to the rule sections for SEC and PEI_CORE. The corresponding rule section names may vary on different platforms but could look like Rule.Common.SEC or Rule.Common.PEI_CORE.

2.2.6 Update the CPU driver on ECP-based platforms

Most Intel® UEFI Development Kit 2010 (Intel® UDK2010) compatibility platforms (ECP) use their own central processing unit (CPU) driver. This driver must be updated during the build process so that the target platform's debugging feature can be enabled.

This step is not needed for native platforms using a CPU driver compliant with the Intel® UDK Debugger Tool solution.

The main task performed by the update is to reserve the original configuration of the interrupt description table (IDT) entries and prevent those entries from being modified.

The update performs these steps:

1. Loads the original IDT table.
2. Calculates the IDT table's entries count.
3. Copies the original IDT table entries to the new IDT table.
4. Updates the code segment (CS) field for the IDT table entries, as the DXE (driver execution) phase is using a different segment descriptor.

5. Fills the rest of IDT entries needed by CPU driver.

If the CPU module is not linked with BaseLib, refer to MdePkg/Library/BaseLib for the implementation of AsmReadIdtr(), AsmWriteIdtr(), and AsmReadCs().

The updated code should follow the same pattern as the following:

```
STATIC
VOID
InitInterruptDescriptorTable (
 VOID
 )
{
 ... ...

 //
 // Get original IDT address and size.
 //
 AsmReadIdtr ((IA32_DESCRIPTOR *) &Idtr);

 //
 // Copy original IDT entry.
 //
 CopyMem (&gIdtTable[0], (VOID *) Idtr.Base, Idtr.Limit + 1);

 //
 // Update all IDT entries to use current CS value
 //

 for (Index = 0; Index < INTERRUPT_VECTOR_NUMBER; Index ++,
CurrentHandler += 0x08) {
  gIdtTable[Index].Bits.Selector  = AsmReadCs();
 }

 ... ...


 AsmWriteIdtr (IdtPtr);

 ... ...

}
```

Figure 12 Updated CPU Driver example

2.2.7 Build the image and update flash memory before debugging source-level code

The image must be built and the flash memory updated before source-level debugging is started. If the macro SOURCE_DEBUG_ENABLE is used to turn on the debug feature conditionally, use the following command to build the image. The following assumes the *Conf/target.txt* file is configured to identify the build target.

```
build -D SOURCE_DEBUG_ENABLE
```

2.2.7.1 For Linux platforms

For Linux platforms, debug x64 code only when using GDB on x64 Linux platforms. When debugging x64 Linux platforms, make sure the firmware image is built on an x64 Linux machine so that the debug symbols are accessible to the GDB.

3 *Setup the Windows Debug Environment*

3.1 Introduction

Setting up the Windows debug environment consists of four general steps:

1. Build the firmware image and burn it to TARGET (described earlier in Chapter 2).
2. Install the Windows Debugger (WinDbg) on HOST.
3. Install the Intel® UDK Debugger Tool on HOST.
4. Connect HOST and TARGET.

Figure 13 shows how the debug components interact on a Windows host during a debug session.

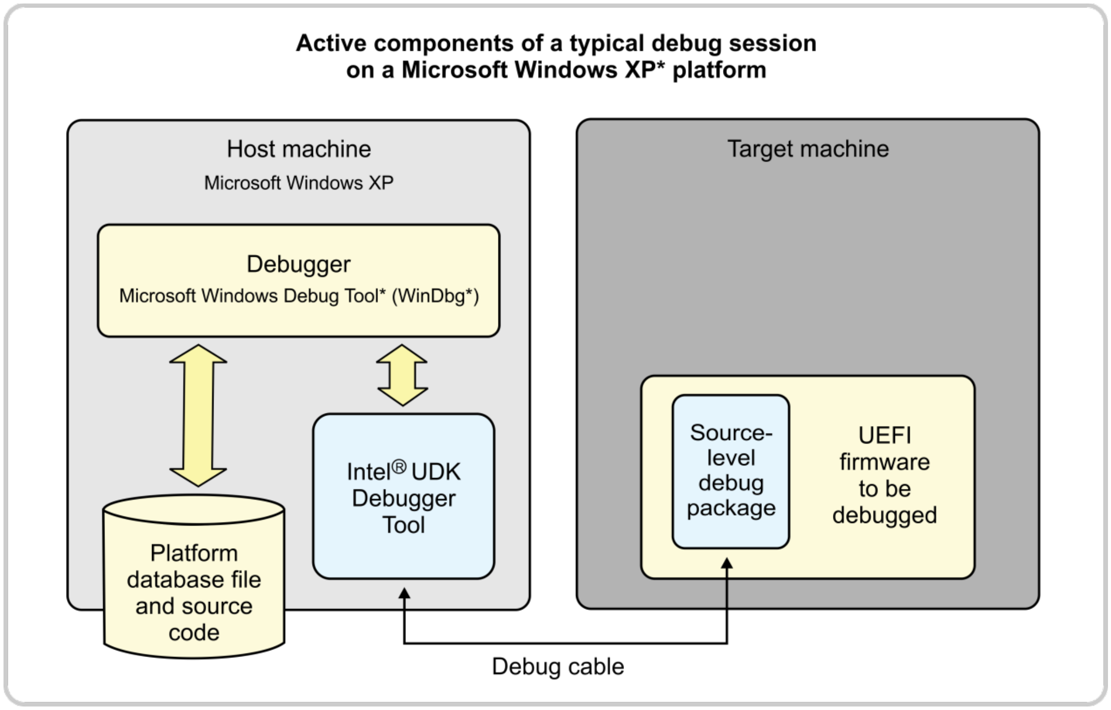

Active components of a typical debug session on a Microsoft Windows XP* platform
Host machine
Microsoft Windows XP
Debugger
Microsoft Windows Debug Tool* (WinDbg*)
Platform database file and source code
Intel® UDK Debugger Tool
Target machine
Source-level debug package
UEFI firmware to be debugged
Debug cable

Figure 13 Active components of a debug session on a Microsoft Windows XP* platform

3.2 Install the Windows Debugger on HOST

Make sure the host machine is configured with Windows XP* (32-bit), SP3, or Windows 7* (64-bit), and the Windows Debugger (WinDbg) to be installed is an X86 version.

3.3 Install the Intel Debugger Tool on HOST

The debug port can be configured during installation.

If the TARGET has more than 16 logical processors, open the SoftDebugger.ini through **Start-> All Programs -> Intel(R) UEFI Development Kit Debugger Tool->Change Configurations**. Change [Target System]/ProcessorCount to specify the number of logical processors in TARGET.

3.4 Connect HOST and TARGET

HOST and TARGET must be connected through a debug channel. The Intel(R) UDK Debugger Tool supports four types of debug channels:

* Serial by a null modem cable

```
[Debug Port]
Channel = Serial
Port = COM1
BaudRate = 115200
FlowControl = 1
```

* USB by a USB 2.0 or 3.0 debug cable

```
[Debug Port]
Channel = USB
```

NOTE: The correct USB 2.0 port on the target machine must be used. Always connect the USB 2.0 debug cable to HOST before connecting to TARGET.

* TCP

```
[Debug Port]
Channel = TCP
Server = 192.168.1.4
Port = 1234
```

* Pipe

```
[Debug Port]
Channel = PIPE
Port = PipeName
```

NOTE: UDK Debugger will open \\\\.\pipe\PipeName for input and output.

Once both HOST and TARGET have been configured and connected, a debug session can be started.

4 Use the Debug Solution on a Windows Platform

4.1 Introduction

This section introduces the Intel® UDK Debugger Tool for the Windows platform, and includes these main discussions:

- General debug flow
- Using the WinDbg debug solution: Start and stop a debug session
- Basic debugging operations, including WinDbg extension commands

4.2 Supported features

The Intel® UDK Debugger Tool for Windows platforms helps in the use of WinDbg to debug Intel® UEFI Development Kit 2010 (Intel® UDK2010) based firmware running on an IA-32 processor. The Intel® UDK Debugger Tool provides the host side software in binary form to support WinDbg remote debugging across a null modem cable or USB debug cable.

With the Intel® UDK Debugger Tool, it is possible to:

- Debug source-level code using WinDbg with a host running a Windows OS.
- Debug could begin as early as late SEC, after temporary RAM set up, for the normal boot path.
- Start debugging SMM (system management mode) code by stopping the target at the next SMI (system management interrupt).
- Setting unresolved breakpoints (also known as pending breakpoints)
- Debugging code running on AP (application processors)
- Late attach
- Using a null modem cable or a USB 2.0 debug cable (also known as a USB host-to-host cable or USB 2.0 debug device)

4.3 General debug flow

There are three general steps in a typical debug process:

1. **Build—**Build the firmware image, including the source-level debug package (provided by Intel). See Figure 14.

CAUTION: Each time the firmware image is rebuilt, the SourceLevelDebug package must be included. If the SourceLevelDebug package is not included, the Intel® UDK Debugger Tool cannot debug the target firmware.

2. **Program—**Program the firmware image into flash memory on the target system.
3. **Launch and debug—**On the host system, launch a debugger that includes the functionality added by the Intel® UDK Debugger Tool.

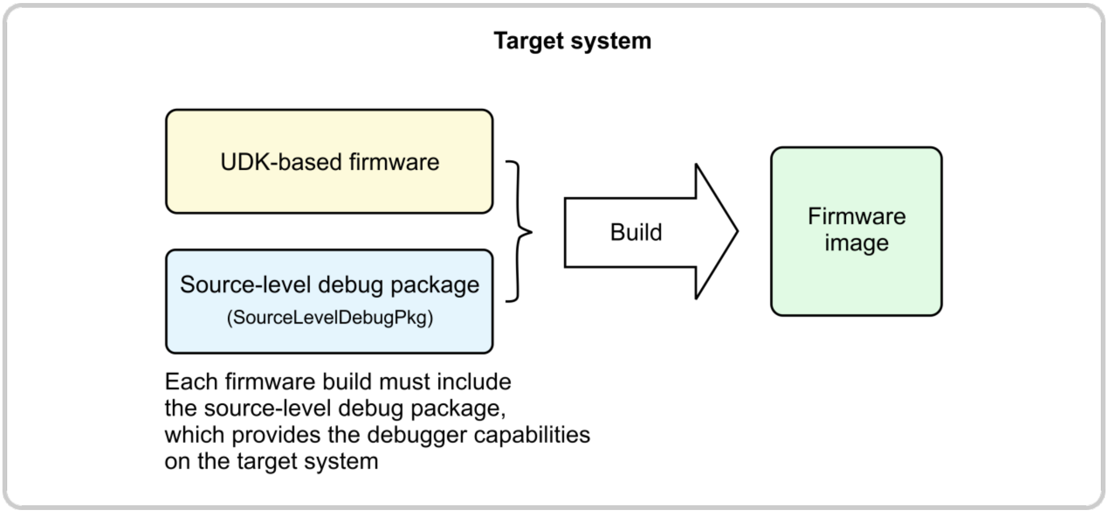

Target system
UDK-based firmware
Source-level debug package
(SourceLevelDebugPkg)
Build
Firmware image
Each firmware build must include the source-level debug package, which provides the debugger capabilities on the target system

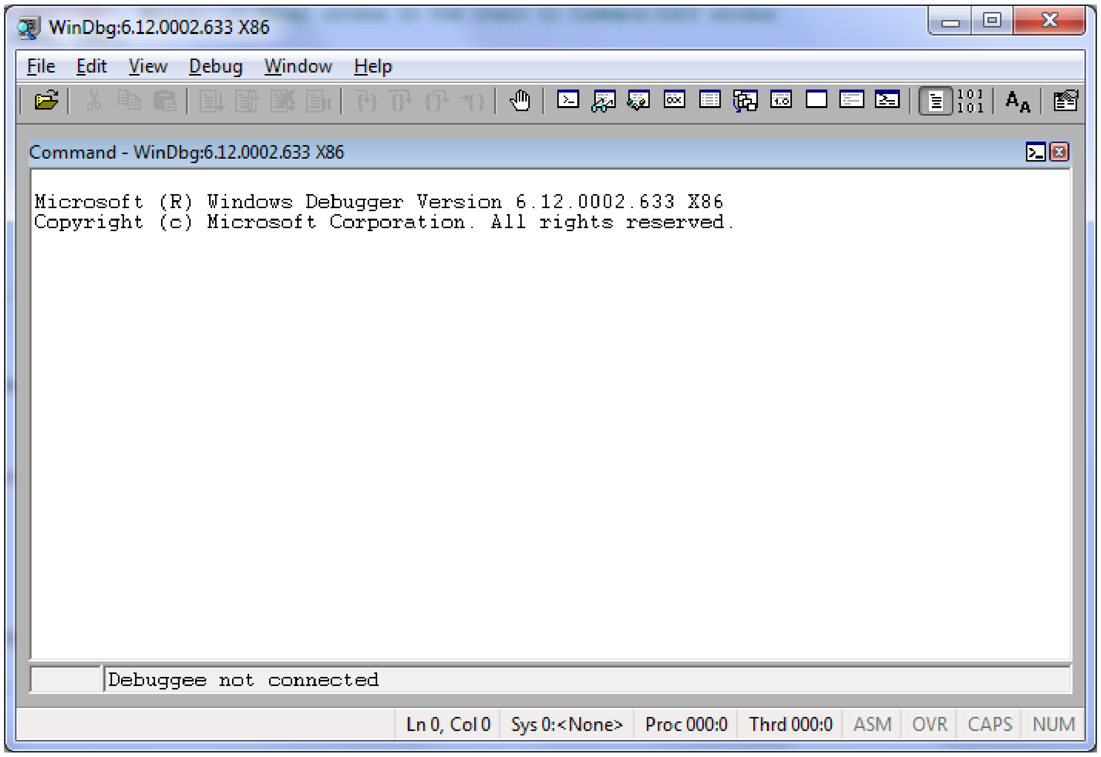
Figure 14 Building a firmware image with the source-level debug package.

The source-level debug package in the firmware build must be included each time the firmware image is built.

4.3.1 Start a WinDbg debug session

Follow these steps to start a WinDbg session:

1. Launch "Start WinDbg using UDK Debugger Tool" from Windows Start -> All Programs -> Intel® UDK Debugger Tool.


WinDbg:6.12.0002.633 X86
File Edit View Debug Window Help
Command - WinDbg:6.12.0002.633 X86

```
Microsoft (R) Windows Debugger Version 6.12.0002.633 X86
Copyright (c) Microsoft Corporation. All rights reserved.
```

```
Debuggee not connected
```

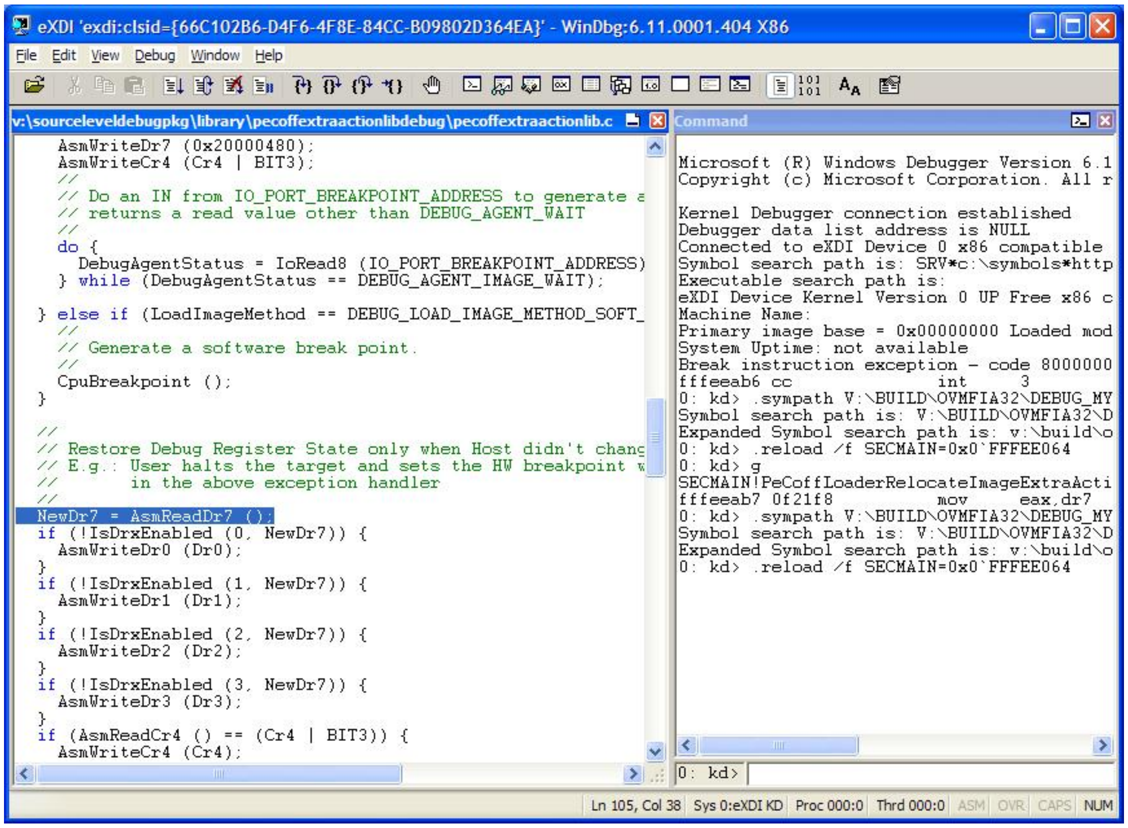
Figure 15 A WinDbg launch window

2. Start up the target system using the Intel® UEFI Development Kit 2010 (Intel® UDK2010) -based firmware image with the debug feature enabled.

If the WinDbg is closed by pressing 'X' before the HOST and TARGET are connected, "windbg.exe" may still be running in the background. Open the Task Manager to terminate the process or the Intel® UDK Debugger Tool may fail to launch.

3. If OVMF is used, refer to the README file under OvmfPkg for details on how to launch an OVFM platform. Be sure to specify the appropriate serial or USB port used to connect with the host.
4. Wait until WinDbg is connected and is ready to accept commands. This will take a few seconds.

If source debugging enabled from SEC, WinDbg should then stop the target in the late SEC phase and load the symbols for SecCore. It will then display the source code. The output should look similar to the following figure although the layout may vary depending on OS, preferences, etc.


eXDI 'exdi:clsid={66C102B6-D4F6-4F8E-84CC-B09802D364EA}' - WinDbg:6.11.0001.404 X86
File Edit View Debug Window Help
v:\sourceleveldebugpkg\library\pecoffextraactionlibdebug\pecoffextraactionlib.c
Command
Ln 105, Col 38 Sys 0:eXDI KD Proc 000:0 Thrd 000:0 ASM OVR CAPS NUM

```
    AsmWriteDr7 (0x20000480);
    AsmWriteCr4 (Cr4 | BIT3);
    //
    // Do an IN from IO_PORT_BREAKPOINT_ADDRESS to generate a
    // returns a read value other than DEBUG_AGENT_WAIT
    //
    do {
      DebugAgentStatus = IoRead8 (IO_PORT_BREAKPOINT_ADDRESS)
    } while (DebugAgentStatus == DEBUG_AGENT_IMAGE_WAIT);

  } else if (LoadImageMethod == DEBUG_LOAD_IMAGE_METHOD_SOFT_
    //
    // Generate a software break point.
    //
    CpuBreakpoint ();
  }

  //
  // Restore Debug Register State only when Host didn't chang
  // E.g.: User halts the target and sets the HW breakpoint w
  //       in the above exception handler
  //
  NewDr7 = AsmReadDr7 ();
  if (!IsDrxEnabled (0, NewDr7)) {
    AsmWriteDr0 (Dr0);
  }
  if (!IsDrxEnabled (1, NewDr7)) {
    AsmWriteDr1 (Dr1);
  }
  if (!IsDrxEnabled (2, NewDr7)) {
    AsmWriteDr2 (Dr2);
  }
  if (!IsDrxEnabled (3, NewDr7)) {
    AsmWriteDr3 (Dr3);
  }
  if (AsmReadCr4 () == (Cr4 | BIT3)) {
    AsmWriteCr4 (Cr4);
```

```
Microsoft (R) Windows Debugger Version 6.1
Copyright (c) Microsoft Corporation. All r

Kernel Debugger connection established
Debugger data list address is NULL
Connected to eXDI Device 0 x86 compatible
Symbol search path is: SRV*c:\symbols*http
Executable search path is:
eXDI Device Kernel Version 0 UP Free x86 c
Machine Name:
Primary image base = 0x00000000 Loaded mod
System Uptime: not available
Break instruction exception - code 8000000
fffeeab6 cc              int     3
0: kd> .sympath V:\BUILD\OVMFIA32\DEBUG_MY
Symbol search path is: V:\BUILD\OVMFIA32\D
Expanded Symbol search path is: v:\build\o
0: kd> .reload /f SECMAIN=0x0`FFFEE064
0: kd> g
SECMAIN!PeCoffLoaderRelocateImageExtraActi
fffeeab7 0f21f8          mov     eax,dr7
0: kd> .sympath V:\BUILD\OVMFIA32\DEBUG_MY
Symbol search path is: V:\BUILD\OVMFIA32\D
Expanded Symbol search path is: v:\build\o
0: kd> .reload /f SECMAIN=0x0`FFFEE064

0: kd>
```

Figure 16 Target stopped at the late SEC phase

Run third-party terminal software to connect the terminal redirection port to get the debug output and terminal output from the firmware.

WinDbg settings can now be configured to set breakpoints. To resume execution on the target, click **go** in the WinDbg tool bar.

When the target execution encounters a breakpoint, WinDbg automatically enters interactive mode. In this mode, it is ready to accept commands. In addition, the corresponding source code is loaded to the source window. To break the execution, click **break** on the WinDbg tool bar.

The target image can still run without a host-side debugger. In this situation, the target image will pause for a few seconds at a time to continue trying to detect the existence of a debug host and will perform a normal boot if a timeout occurs.

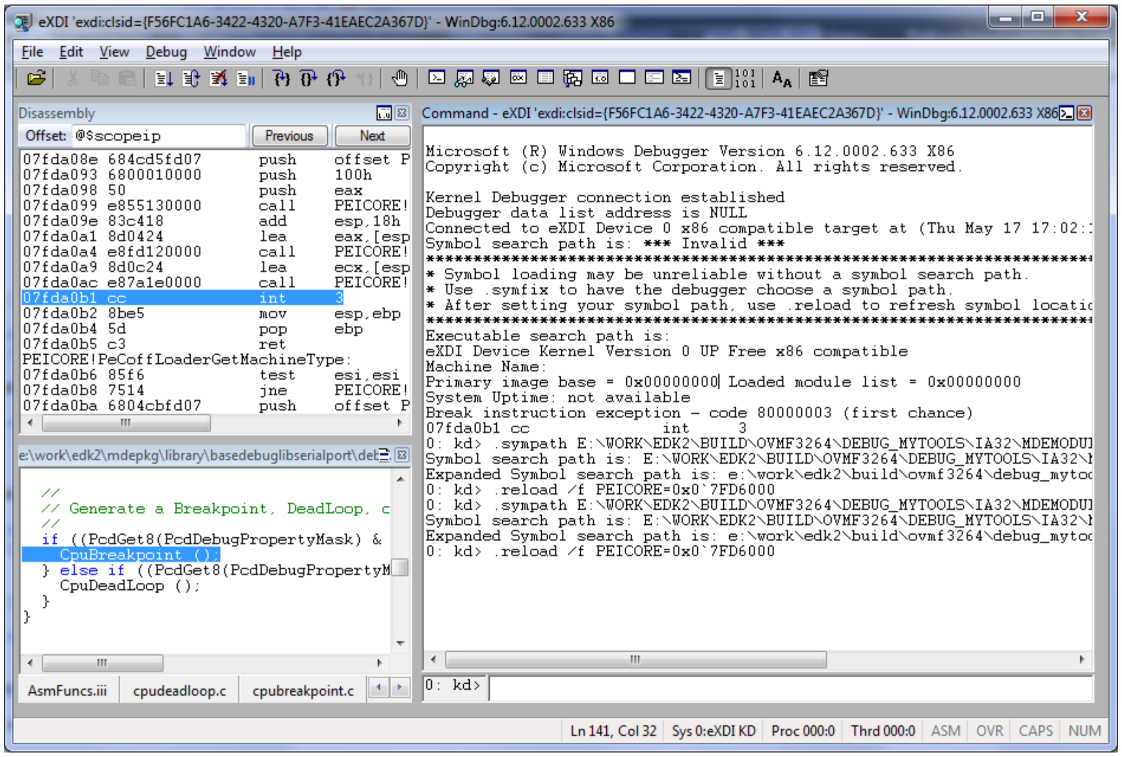
4.3.2 Start a WinDbg session using late attach

Follow these steps to start a WinDbg session:

1. Start up the target system using the Intel® UEFI Development Kit 2010 (Intel® UDK2010)-based firmware image
   with the debug feature enabled.

2. Launch “Start WinDbg using UDK Debugger Tool” from Windows Start -> All Programs -> Intel® UDK Debugger Tool.
3. Wait a few seconds until WinDbg is connected and ready to accept commands.

WinDbg should stop the target and load the symbols for the current module. It will then display source code looking similar to the following figure, allowing for different machines and user preferences.


eXDI 'exdi:clsid={F56FC1A6-3422-4320-A7F3-41EAEC2A367D}' - WinDbg:6.12.0002.633 X86
File Edit View Debug Window Help
Disassembly
Offset: @$scopeip
Previous
Next
e:\work\edk2\mdepkg\library\basedebuglibserialport\del
AsmFuncs.iii
cpudeadloop.c
cpubreakpoint.c
Command - eXDI 'exdi:clsid={F56FC1A6-3422-4320-A7F3-41EAEC2A367D}' - WinDbg:6.12.0002.633 X86
Ln 141, Col 32
Sys 0:eXDI KD
Proc 000:0
Thrd 000:0
ASM
OVR
CAPS
NUM

```
07fda08e 684cd5fd07      push    offset P
07fda093 6800010000      push    100h
07fda098 50              push    eax
07fda099 e855130000      call    PEICORE!
07fda09e 83c418          add     esp,18h
07fda0a1 8d0424          lea     eax,[esp
07fda0a4 e8fd120000      call    PEICORE!
07fda0a9 8d0c24          lea     ecx,[esp
07fda0ac e87a1e0000      call    PEICORE!
07fda0b1 cc              int     3
07fda0b2 8be5            mov     esp,ebp
07fda0b4 5d              pop     ebp
07fda0b5 c3              ret
PEICORE!PeCoffLoaderGetMachineType:
07fda0b6 85f6            test    esi,esi
07fda0b8 7514            jne     PEICORE!
07fda0ba 6804cbfd07      push    offset P
```

```
  //
  // Generate a Breakpoint, DeadLoop, c
  //
  if ((PcdGet8(PcdDebugPropertyMask) &
    CpuBreakpoint ();
  } else if ((PcdGet8(PcdDebugPropertyM
    CpuDeadLoop ();
  }
}
```

```
Microsoft (R) Windows Debugger Version 6.12.0002.633 X86
Copyright (c) Microsoft Corporation. All rights reserved.

Kernel Debugger connection established
Debugger data list address is NULL
Connected to eXDI Device 0 x86 compatible target at (Thu May 17 17:02:1
Symbol search path is: *** Invalid ***
***********************************************************************
* Symbol loading may be unreliable without a symbol search path.
* Use .symfix to have the debugger choose a symbol path.
* After setting your symbol path, use .reload to refresh symbol locatic
***********************************************************************
Executable search path is:
eXDI Device Kernel Version 0 UP Free x86 compatible
Machine Name:
Primary image base = 0x00000000 Loaded module list = 0x00000000
System Uptime: not available
Break instruction exception - code 80000003 (first chance)
07fda0b1 cc              int     3
0: kd> .sympath E:\WORK\EDK2\BUILD\OVMF3264\DEBUG_MYTOOLS\IA32\MDEMODUI
Symbol search path is: E:\WORK\EDK2\BUILD\OVMF3264\DEBUG_MYTOOLS\IA32\I
Expanded Symbol search path is: e:\work\edk2\build\ovmf3264\debug_mytoc
0: kd> .reload /f PEICORE=0x0`7FD6000
0: kd> .sympath E:\WORK\EDK2\BUILD\OVMF3264\DEBUG_MYTOOLS\IA32\MDEMODUI
Symbol search path is: E:\WORK\EDK2\BUILD\OVMF3264\DEBUG_MYTOOLS\IA32\I
Expanded Symbol search path is: e:\work\edk2\build\ovmf3264\debug_mytoc
0: kd> .reload /f PEICORE=0x0`7FD6000
```

```
0: kd>
```

Figure 17 Target stopped due to late attach

4.3.3 End the WinDbg session

To end a WinDbg debug session, use the following steps:

1. Halt the TARGET if the TARGET is running
2. Run ‘q’ command in WinDbg

Closing WinDbg without using the above steps leaves the TARGET platform in an intermediate state and it cannot be reattached until rebooted.

4.4 Basic WinDbg debugging operations

When the target reaches a breakpoint or stops after a **break** command is issued, the debugger loads the source of the current module as well as all other modules that have executed (if possible or applicable).

This list briefly describes basic debugging operations available through WinDbg:

- Open source code and set/clear breakpoints.
- Open a disassembly window to see instructions around the current instruction pointer (IP).
- Open a memory window to read or write memory.

In order to prevent a system hang on some platforms, accessing 0-128M memory before physical memory is ready will not cause a similar memory access on the target system. Instead, dummy data is displayed. The filtering capability is disabled during the transition from pre-memory to post-memory PEI. For example, the memory in OVMF is functional from reset and displays actual memory contents.

4.4.1 Basic procedures

1. Open a local variable window to read (or to write) local variables and function parameters.

   — The /Od compiler option disables some optimization and makes sure all local variables are displayed in the output code. At optimization levels above /Od, local variables optimized into registers are not visible.

   — Local variables stored on the stack may still been seen. The same conditions apply to parameters passed into a function.

2. Open a register window to read/write general purpose registers.
3. Open a call stack window to see the call stack and/or parameter names and/or values.
4. Issue **step into**, **step over**, or **go** commands to tell the target to execute.

   —When using WinDbg on systems with multiple processors, **step into** and **step over** will cause only one processor to execute and leave other processors at the stopped state. The **go** command causes all processors to start execution.

   —Only one processor at a time can be debugged when using DBG.

5. Issue the **break** command while the target is running to break in.
   On multiple processor systems (WinDbg only), all active processors will be stopped.

6. Open a Processes and Threads window to view and specify the current processor to emulate.

   — On multiple processor systems (WinDbg only), each logical processor is emulated as a separate thread.

7. Use the Watch window to look at global variables (i.e. gBS, gST, gRT, gDS).

4.4.2 WinDbg extension commands

The following extension commands add additional functionalities to WinDbg to assist debugging target firmware. They are provided by the UdkExtension.dll.

smmentrybreak

smmentrybreak [on|off]

Controls whether the target should stop the next time SMM mode is entered.

- Set the command to on to make the target stop on the next SMM entry.
- Set the command to *off* to prevent the target from stopping on the next SMM entry.

bootscriptentrybreak

bootscriptentrybreak [on|off]

Controls whether the target should stop before executing boot script.

- Set the command to on to make the target stop before executing boot script.
- Set the command to off to prevent the target from stopping before executing boot script.

resetdelay

resetdelay <time in second>

Specifies the time to delay between the debugger's reset on the target system and the start of the WinDbg session's setup on the host.

For example, use this command to set the delay value to a non-0 value when a platform is setting up a timer and not clearing it in early SEC. Without a delay, the hardware reset could interfere with the debug session. Setting the delay to a value larger than the timer timeout value may resolve this problem.

Typically, a delay of 10 seconds is enough. This can help avoid the need to delay each reboot by clearing the timer early in the SEC phase.

cpuid

cpuid [Index] [SubIndex]

Retrieves CPUID information.

Options:

Index

Value of EAX priori to executing CPUID instruction (defaults to 1, 32-bit max, base 16)

SubIndex

Value of ECX priori to executing CPUID instruction (defaults to 0, 32-bit max, base 16)

loadthis

loadthis [HexAddress]

Load debug symbol for the given address.

Options:

HexAddress

Address you wish to load debug symbol for. If no argument is given, the command loads debug symbol for the current instruction pointer.

The commands below are executed with **!py** prefix, for example, !py pci.

!py mmio

!py mmio Address Width [Value]

Access the memory mapped IO space.

Options:

Address

MMIO address to access.

Width

Access width 1, 2, 4 or 8.

Value

Content to write to the MMIO address when specified.

!py pci

!py pci [Bus [Dev [Func]]]

Display PCI device list or PCI function configuration space.

Options:

Bus

When only Bus is specified, it is the starting bus number for enumeration; 0 by default if not specified. Otherwise the bus number of the PCI device whose configuration space is to be dumped.

Dev

Device number of the PCI device whose configuration space is to be dumped.

Func

Function number of the PCI device whose configuration space is to be dumped; 0 by default if not specified.

!py mtrr

!py mtrr

Dump the MTRR setting of current processor.

!py DumpHobs

!py DumpHobs [HobStartAddress]

Dump content of HOB list.

Options:

HobStartAddress

The start address of HOB list. The first HOB in the HOB list must be the Phase Handoff Information Table (PHIT) HOB. When HobStartAddress is not specified, HOB list will be got from EFI Configuration Table and dumped.

!py DumpVariable

!py DumpVariable [VariableName]

Dump content of UEFI variable on flash.

Options:

VariableName

The name of variable. If a variable name is specified, the contents of this variable will be dumped. If a variable name is not specified, the contents of all UEFI variables on flash will be dumped.

!py DumpS3Script S3ScriptTableAddress

!py DumpS3Script S3ScriptTableAddress

Dump content of S3 boot script.

Options:

S3ScriptTableAddress

The base address of S3 boot script table.

!py ShowEfiDevicePath DevicePathAddress

!py ShowEfiDevicePath DevicePathAddress

Convert a UEFI device path to text.

Options:

DevicePathAddress

The start address of a UEFI device path.

5 Known Limitations & Issues for Windows platforms

5.1 Known limitations

The debug solution has the following known limitations on a Windows platform:

- Firmware output (through the debug channel) should not contain non-ASCII characters.
- Do not use more than three user-specified breakpoints in the SEC/PEI phase since hardware breakpoints are used for code executing from read-only memory.
- Code occurring before the source-level debug package is initialized cannot be debugged.
  - This includes early SEC code, early SMM code, and other code.
- The TE image header is emulated as a PE header for WinDbg. As a result, the contents of the TE header are not visible to WinDbg.
- During the SEC, PEI phases, only one processor (the BSP, or boot strap processor) can be debugged.
  - This also applies to the DXE phase before the Multiple Processor (MP) Services Protocol is installed., Switching to other active processors (AP, or Additional Processors) is possible while in the DXE phase but after the MP Services Protocol has been installed.
- Debugging is not supported if the CPU is executing in 16-bit real mode.
- If the CPU is executing with interrupts disabled, breaks from the host to the target are not supported.
- When using the USB debug cable as the debug communication channel, USB devices cannot be detected on any other USB ports associated with the same EHCI controller.
  - USB ports associated with other EHCI controllers are not impacted.
- Only AP code invoked by the Platform Initialization Multiprocessor Services Protocol can be debugged.

— For example, on EdkCompatibilityPkg-based platforms, AP code invoked through the Framework Multiprocessor Services Protocol cannot be debugged.

6 Setup the Linux Debug Environment

6.1 Introduction

Setting up the Linux debug environment consists of four general steps:

1. Build the firmware image and burn it to TARGET (described earlier in Section 3).
2. Rebuild GDB on HOST.
3. Install the Intel® UDK Debugger Tool on HOST.
4. Connect the HOST and TARGET.

The following figure shows how the debug components interact on a Linux host during a debug session.

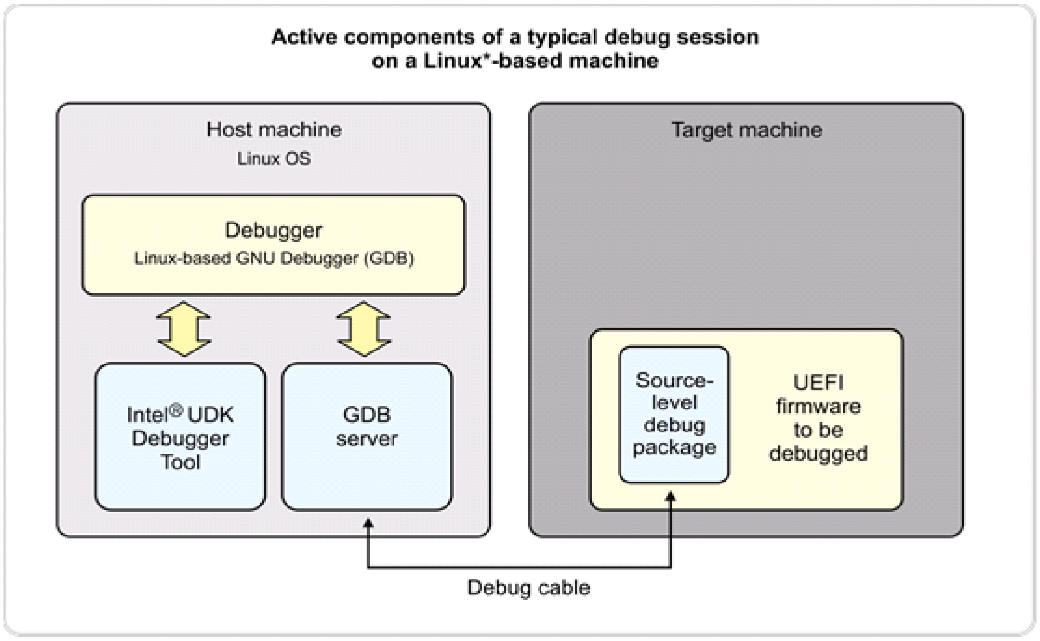

Active components of a typical debug session on a Linux*-based machine
Host machine
Linux OS
Debugger
Linux-based GNU Debugger (GDB)
Intel® UDK Debugger Tool
GDB server
Target machine
Source-level debug package
UEFI firmware to be debugged
Debug cable

Figure 18 Active components of a debug session on a Linux platform

6.2 Rebuild GDB on HOST

For Linux platforms, x64 code can only be debugged when using GDB on x64 Linux platforms. When debugging x64 platforms, make sure to build the firmware image on an x64 Linux machine so that the debug symbols are accessible to the GDB.

GDB supports the unresolved breakpoint setting by design, but it needs to be rebuilt to support this feature because the GDB pre-installed doesn't include the Expat XML parsing library. Using the GDB pre-installed doesn't block the other features.

Use "--target=x86_64-w64-mingw32 --with-expat" as the parameter to configure the GDB before make so GDB can use the Expat XML parsing library. This library may be included in the end user's Linux distribution. If not, it can be downloaded from http://expat.sourceforge.net.

6.3 Install the Intel Debugger Tool on HOST

The debug port can be configured during installation.

If the TARGET has more than 16 logical processors, open the SoftDebugger.ini through **Start-> All Programs -> Intel(R) UEFI**

Development Kit Debugger Tool->Change Configurations. Change [Target System]/ProcessorCount to specify the number of logical processors in TARGET.

6.4 Connect HOST and TARGET

HOST and TARGET must be connected through a debug channel. The Intel(R) UDK Debugger Tool supports four types of debug channels:

```
 * Serial by a null modem cable
   [Debug Port]
   Channel = Serial
   Port = COM1
   BaudRate = 115200
   FlowControl = 1
```

```
 * USB by a USB 2.0 or 3.0 debug cable
   [Debug Port]
   Channel = USB
```

NOTE: USB 2.0 debug cable support is provided by Linux kernel starting from 2.6.20. The correct USB 2.0 port on the target machine must be used. Always connect the USB 2.0 debug cable to HOST before connecting to TARGET.

```
 * TCP
   [Debug Port]
   Channel = TCP
   Server = 192.168.1.4
   Port = 1234
```

```
 * Pipe
   [Debug Port]
   Channel = PIPE
   Port = PipePath
```

NOTE: UDK Debugger will open PipePath.in for output and PipePath.out for input.

Once both HOST and TARGET have been configured and connected, a debug session can be started.

7 Use the Debug Solution on a Linux Platform

7.1 Introduction

This section explains how to perform basic debug operations. It includes these key discussions:

- Supported features for Linux platforms as well as features not yet implemented
- Using the Linux/GDB debug solution to Start, reset, and stop a debug session
- Basic debugging operations including GDB extension commands

7.2 Supported features for Linux platforms

The Intel® UDK Debugger Tool for Linux platforms helps in the use of GDB to debug Intel® UEFI Development Kit 2010 (Intel® UDK2010) based firmware running on an IA-32 processor. The Intel® UDK Debugger Tool provides the host side software in binary form to support GDB remote debugging across a null modem cable.

With the Intel® UDK Debugger Tool, it is possible to:

- Debug source-level code using GDB with a host running a Linux OS.
- Debug could begin as early as late SEC, after temporary RAM set up, for the normal boot path.
- Start debugging SMM (system management mode) code by stopping the target at the next SMI (system management interrupt).
- Use a null modem cable as a debug cable.
- Set unresolved breakpoints (also known as pending breakpoints)
- Debug code running on AP (additional processors)
- Late attach

7.2.1 Unresolved breakpoint setting in Linux

By design, GDB supports the unresolved breakpoint setting. However, the end-user needs to recompile the GDB to include the Expat XML parsing library since a pre-installed GDB does not include it. Using the GDB as pre-installed doesn't block the other features.

Use "`--target=x86_64-w64-mingw32 --with-expat`" as the parameter to configure the GDB before Make so it can use the Expat XML parsing library. The library may be included in the end user's Linux distribution or downloaded from http://expat.sourceforge.net/

```
(gdb) source  work/Debugger/Src/NewHost/GdbScript/edk2_gdb_script
##############################################################

# This gdb configuration file contains settings and scripts

# for debugging UDK firmware.

# Setting pending breakpoints is supported.

##############################################################
```

Figure 19 Output when sourcing udk-script if GDB includes Expat XML parsing library

```
(gdb) source /opt/intel/udkdebugger/script/udk-gdb-script

##############################################################

# This gdb configuration file contains settings and scripts

# for debugging UDK firmware.

# WARNING: Setting pending breakpoints is NOT supported!

# Load additional command!

##############################################################
```

Figure 20 Output when sourcing udk-script if GDB doesn't include Expat XML parsing library

```
(gdb) b PeiDispatcher

Function "PeiDispatcher" not defined.

Make breakpoint pending on future shared library load? (y or [n]) y



Breakpoint 1 (PeiDispatcher) pending.

(gdb) c

Continuing.



Breakpoint 1, PeiDispatcher (SecCoreData=0x7ffac, Private=0x7f548)

    at
/home/ray/work/AllPackagesDev/MdeModulePkg/Core/Pei/Dispatcher/Dispatcher.c:623

623     {
```

Figure 21 Add the unresolved breakpoint in GDB

7.3 General debug flow

There are three general steps in the typical debug process:

1. **Build** the firmware image, including the source-level debug package (provided by Intel). See Figure 22

CAUTION: Each time the firmware image is rebuilt, the source-level debug package must be included. If the debug package is not included, the Intel® UDK Debugger Tool cannot be used to debug the target firmware. The files to edit for the source-level debug package are included in the build image. Those files ensure that the firmware build has debug capability until debug-related changes are explicitly removed from the files.

2. **Program** the firmware image into flash memory on the target system.
3. **Launch and debug** on the host system with a debugger that includes the functionality added by the Intel® UDK Debugger Tool.

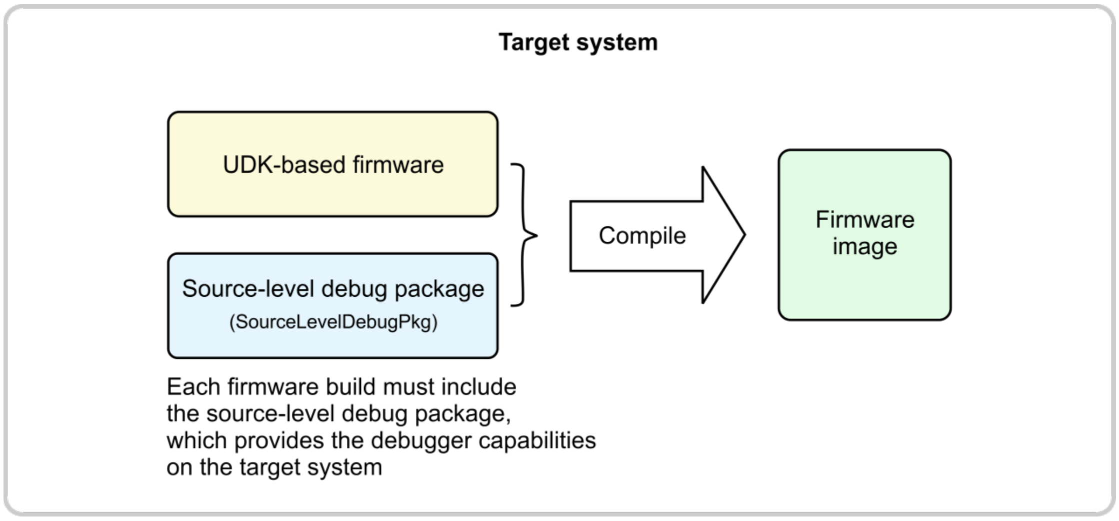

Target system
UDK-based firmware
Source-level debug package
(SourceLevelDebugPkg)
Compile
Firmware image
Each firmware build must include the source-level debug package, which provides the debugger capabilities on the target system

Figure 22 Compiling a firmware image with the source-level debug package

The source-level debug package (provided by Intel) must be included in the firmware build each time you compile the image.

7.4 Using the Linux/GDB debug solution

This discussion explains how to start, restart, and end a debug session.

7.4.1 Start a GDB debug session

Follow these steps to start a GDB debug session:

1. At the shell prompt, start the GDB server by entering the appropriate command similar to the following:

```
foo@foo:~$ [/usr/bin/]udk-gdb-server
```

   — The command line is a symbolic link to /opt/intel/udkdebugger/bin/udk-gdb-server.
   — A message similar to the following should appear:

```
UDK GDB Server - Version 1.2
Waiting for the connection from the Target...
Debugging through serial port (/dev/ttyS0:115200:Hardware)
Redirect TARGET output to TCP port (20715).
```

2. Power up the target system. The system must include the Intel® UEFI Development Kit 2010 (Intel® UDK2010)-based firmware image built with the source-level debug package and it must have the debug feature enabled.
3. Wait one or two seconds until the GDB server successfully connects to the target debugger. A message similar to the following should appear.

The message indicates that the GDB server has successfully connected and, in this example, is listening on TCP port 1234.

```
GdbServer on <HOST> is waiting for connection on port 1234
Connect with 'target remote <HOST>:1234'
```

4. GDB communicates with the target system via the GDB server. When prompted by the GDB server, connect the GDB to the GDB server by entering the following command in GDB:
   - In the command line, replace <HOST> with the name of the target machine.

```
target remote <HOST>:1234
```

5. Run third-party terminal software to connect the terminal redirection port to get the debug output and terminal output from the firmware.
6. Enter the following command in GDB to load the GDB extension for the Intel® UDK Debugger Tool:

```
source /opt/intel/udkdebugger/bin/udk-gdb-script
```

   - The GDB extension commands can now be used to begin debugging the target firmware at the source level. Extension commands are described at the end of this section.

7.4.2 Start a GDB debug session using late attach

1. Power up the target system. The system must include the Intel® UEFI Development Kit 2010 (Intel® UDK2010)-based firmware image built with the source-level debug package and it must have the debug feature enabled.
   - At the shell prompt, start the GDB server by entering the appropriate command similar to the following:

```
foo@foo:~$ [/usr/bin/]udk-gdb-server
```

   - This command line is a symbolic link to /opt/intel/udkdebugger/bin/udk-gdb-server.
   - A message similar to the following should appear:

```
UDK GDB Server - Version 1.2
Waiting for the connection from the Target...
Debugging through serial port (/dev/ttyS0:115200:Hardware)
Redirect TARGET output to TCP port (20715).
GdbServer on <HOST> is waiting for connection on port 1234
Connect with 'target remote <HOST>:1234'
```

2. GDB communicates with the target system via the GDB server. When prompted by the GDB server, connect the GDB to the GDB server by entering the following command in GDB.
   - In the command line, replace <HOST> with the name of the target machine.

```
target remote <HOST>:1234
```

3. Run third-party terminal software to connect the terminal redirection port and get the debug and terminal output from the firmware.
4. Enter the following command in GDB to load the GDB extension for the Intel® UDK Debugger Tool:

```
source /opt/intel/udkdebugger/bin/udk-gdb-script
```

The GDB extension commands can now be used to begin debugging the target firmware at the source level. Extension commands are described at the end of this section.

7.4.3 End the GDB debug session

To end a GDB debug session, follow these steps:

1. Halt the TARGET if the TARGET is running
2. In GDB, enter the `quit` command to end the debugging session.

```
(gdb) quit
A debugging session is active.
        Inferior 1 [Remote target] will be detached.
Quit anyway? (y or n) y
qTStatus: Remote connection closed
user@user-Ubuntu11-64:~$
```

Figure 23 Detach in GDB

Closing GDB without running the “quit” command leaves the TARGET firmware in an intermediate state and it cannot be reattached until restarted.

7.5 Basic GDB debugging operations

The Intel® UDK Debugger Tool supports GDB operations for Linux platforms, including these critical operations:

- *Embed a breakpoint in the source code.*
  - Adding the CpuBreakpoint() statement to the source code allows the GDB to enter interactive mode when the target executes the line.
- *Add a function breakpoint in a debug session.*
  - As long as a module's symbol file is loaded, use of the break command to set a breakpoint for a function within the module is permissible. Command syntax for the **break** command is:

```
break <function_name>
```

  - In the following example, a breakpoint is added to the IoBitFieldRead16 function:

```
foo@foo:~$ break IoBitFieldRead16
```

7.5.1 GDB extension commands

The following extension commands add additional functionality to GDB to assist debugging the target firmware. They are provided by the udk-gdb-script.

set smmentrybreak

set smmentrybreak on|off

Specify whether or not the debugger stops the target machine when entering SMM.

set bootscriptentrybreak

set bootscriptentrybreak on|off

Specify whether or not the debugger stops the target machine before executing boot script.

set resetdelay

set resetdelay <1~20>

Specify the delay the host system will wait to begin running again after the target system resets.

cpuid

cpuid [Index] [SubIndex]

Retrieves CPUID information.

Options:

Index

Value of EAX priori to executing CPUID instruction (defaults to 1, 32-bit max, base 16)

SubIndex

Value of ECX priori to executing CPUID instruction (defaults to 0, 32-bit max, base 16)

resettarget

resettarget

Resets the target system.

refresharch

refresharch

Queries the target processor for the processor mode: i386 (IA32) or i386x86-64 (x64).

The following four commands are only provided when GDB doesn't support setting an unresolved breakpoint.

info modules

info modules [ModuleName [ModuleName [...]]]

Lists information about the loaded modules or the specified module(s).

loadthis

loadthis

Loads the symbol file for the current IP (Instruction Pointer) address.

loadimageat

loadimageat <hex-address>

Loads the symbol file for the specified address.

loadall

loadall

Loads symbols for all loaded modules.

The commands below are executed with **py** prefix, for example, py pci.

py mmio

py mmio Adress Width [Value]

Access the memory mapped IO space.

Options:

Address

MMIO address to access.

Width

Access width 1, 2, 4 or 8.

Value

Content to write to the MMIO address when specified.

py pci

py pci [Bus [Dev [Func]]]

Display PCI device list or PCI function configuration space.

Usage: py pci [Bus [Dev [Func]]]

Options:

Bus

When only Bus is specified, it is the starting bus number for enumeration; 0 by default if not specified. Otherwise the bus number of the PCI device whose configuration space is to be dumped.

Dev

Device number of the PCI device whose configuration space is to be dumped.

Func

Function number of the PCI device whose configuration space is to be dumped; 0 by default if not specified.

py mtrr

py mtrr

Dump the MTRR setting of current processor.

Usage: py mtrr

py DumpHobs

py DumpHobs [HobStartAddress]

Dump content of HOB list.

Usage: py DumpHobs [HobStartAddress]

Options:

HobStartAddress

The start address of HOB list. The first HOB in the HOB list must be the Phase Handoff Information Table (PHIT) HOB. When HobStartAddress is not specified, HOB list will be got from EFI Configuration Table and dumped.

py DumpVariable

py DumpVariable [VariableName]

Dump content of UEFI variable on flash.

Usage: py DumpVariable [VariableName]

Options:

VariableName

The name of variable. If a variable name is specified, the contents of this variable will be dumped. If a variable name is not specified, the contents of all UEFI variables on flash will be dumped.

py DumpS3Script S3ScriptTableAddress

py DumpS3Script S3ScriptTableAddress

Dump content of S3 boot script.

Usage: py DumpS3Script [S3ScriptTableAddress]

Options:

S3ScriptTableAddress

The base address of S3 boot script table.

py ShowEfiDevicePath DevicePathAddress

py ShowEfiDevicePath DevicePathAddress

Convert UEFI device path to text.

Usage: py ShowEfiDevicePath DevicePathAddress

Options:

DevicePathAddress

The start address of UEFI device path.

7.5.1.1 Data Breakpoint

For Linux developers, three extension commands—*iowatch*, *info iowatchpoints*, and *delete iowatchpoints* are available to add, show and delete IO breakpoints. Note that they are not available in Windows because, by design, GDB doesn't use the IO concept.

```
(gdb) help iowatch
Set a watchpoint for an IO address.
Usage: iowatch/SIZE PORT
A watchpoint stops execution of your program whenever the
IO address is either read or written.
PORT is an expression for the IO address to Access.
SIZE letters are b(byte), h(halfword), w(word).
VALUE is an expression to write to the PORT.
(gdb) iowatch/b 0x80
IO Watchpoint 1: 80(1)
```

Figure 24 Add IO watch point in GDB

```
(gdb) help info iowatchpoints
Status of specified IO watchpoint (all watchpoints if no
argument).
(gdb) info iowatchpoints
Num     Port    Size
1       0x80    1
```

Figure 25 List IO watch point in GDB

```
(gdb) help delete iowatchpoints
Delete some IO watchpoints.
Argument is IO watchpoints number.
To delete all IO watchpoints, give no argument.
(gdb) delete iowatchpoints 1
Succeeded to delete IO watchpoint 1
```

Figure 26 Delete IO watch point in GDB

8 Known Limitations & Issues for Linux platforms

8.1 Known limitations

The debug solution has these known limitations on a Linux platform:

- Firmware output (through the debug channel) should not contain non-ASCII characters.
- Do not use more than three user-specified breakpoints in the SEC/PEI phase since hardware breakpoints are used for code executing from read-only memory.
- Code occurring before the source-level debug package is initialized cannot be debugged.
  - This includes early SEC code, early SMM code, and other code.
- During the SEC, PEI phases, only one processor (the BSP, or boot strap processor) can be debugged.
  - This also applies to the DXE phase before the Multiple Processor (MP) Services Protocol is installed. While in the DXE phase, after the MP Services Protocol has been installed, switching to other active processors (AP, or Additional Processors) is possible.
- Debugging is not supported if the CPU is executing in 16-bit real mode.
- If the CPU is executing with interrupts disabled, breaks from the host to the target are not supported.
- When using the USB debug cable as the debug communication channel, USB devices cannot be detected on any other USB ports associated with the same EHCI controller.
  - USB ports associated with other EHCI controllers are not impacted.
- Only AP code invoked by the Platform Initialization Multiprocessor Services Protocol can be debugged.
  - For example, on EdkCompatibilityPkg-based platforms, AP code invoked through the Framework Multiprocessor Services Protocol cannot be debugged.

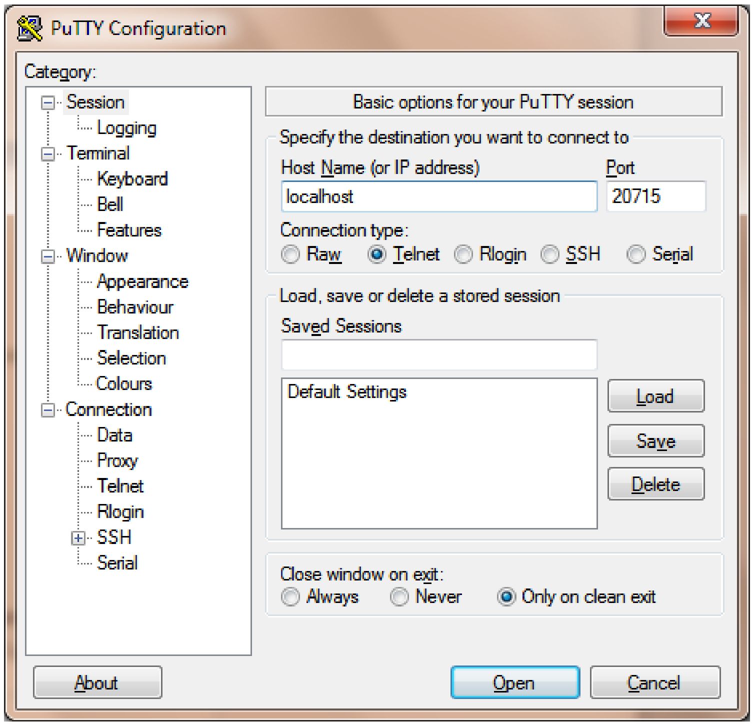
9 Debug Tips & Techniques

9.1 Introduction

The debugging tips and techniques described in this section generally apply to both Windows and Linux systems. Any platform specific differences are explained in the topic.

9.2 Terminal redirection

Terminal I/O can be redirected to a local TCP port (default port is 20715), which can be connected to using a third-party terminal software such as PuTTY, as shown below. The output from the TARGET firmware can be redirected to the terminal software and the end-user input from the terminal software can be redirected to the TARGET firmware.



Specify the destination you want to connect to

Host Name (or IP address): localhost

Port: 20715

Connection type: Raw [✓ Telnet] Rlogin SSH Serial

Load, save or delete a stored session

Saved Sessions

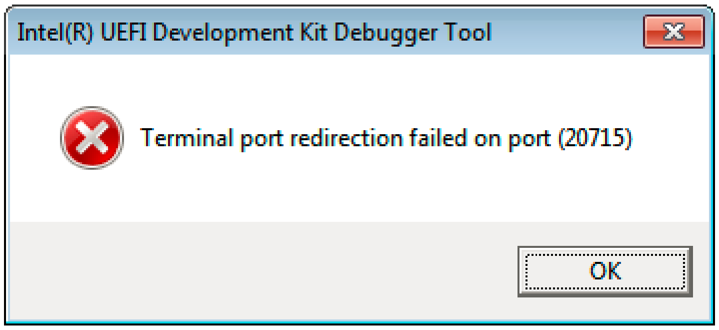
Default Settings

Close window on exit: Always Never [✓ Only on clean exit]

Figure 27 Using PuTTY to connect to the terminal redirection port

When source level debug is enabled, the debugger uses the serial port for command/packet communication, and PuTTY cannot connect to the serial port because it's already in use by the debugger. To enable the ability to type in shell commands from PuTTY, the debugger redirects the firmware output to the TCP port and redirects the input from the TCP port to firmware. This enables a user to connect PuTTY to the TCP port for typing in shell commands and viewing firmware output.

If the tool is unable to use the selected TCP Port, it displays an error message as shown in Figure 28. To correct this issue, modify the configuration file to use a different TCP port as shown in the following example.



Terminal port redirection failed on port (20715)

Figure 28 Error displayed when the terminal redirection port cannot be opened

```
[Features]
TerminalRedirectionPort = 30000
```

Figure 29 Sample configuration for using 30000 as the terminal redirection port

The following figure illustrates the data flow between TARGET and HOST from the end-user's perspective. The TCP Port is actually created by the Intel® UDK Debugger Tool.

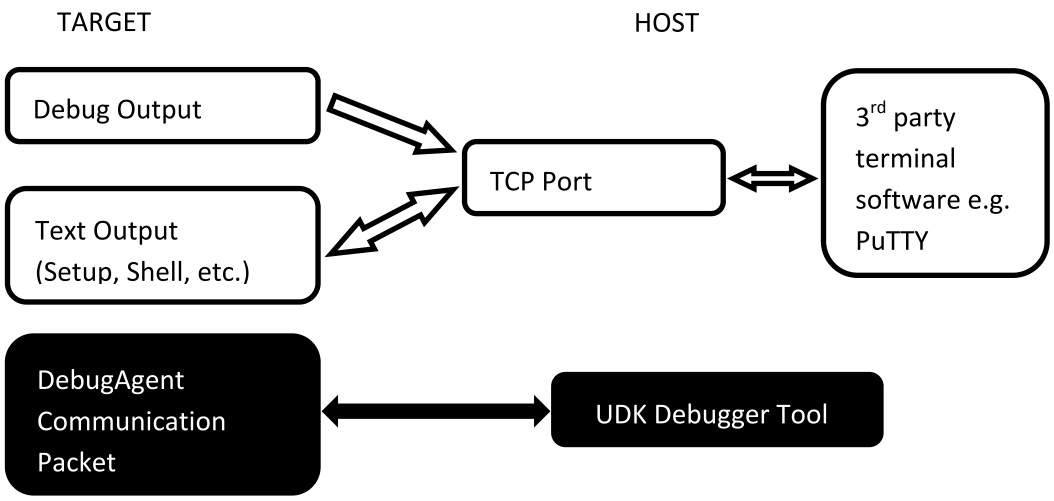

TARGET
HOST
Debug Output
Text Output (Setup, Shell, etc.)
TCP Port
3rd party terminal software e.g. PuTTY
DebugAgent Communication Packet
UDK Debugger Tool

Figure 30 Data flow between TARGET and HOST

9.3 Trace

With Trace, the Intel® UDK Debugger Tool logs the debug output during execution. When a tool issue occurs, the log can be sent back to the developer for root causing.

Tracing is turned off by default. Enable it in your configuration file with the following code snippet:

```
[Debug]
Trace=0x1f
```

The log file is located in the root of the current user's home directory. For example, with Windows XP*, the log file is in C:\Document and Settings\<userid>\udk-debugger-trace.log.

- For Windows, the log file is in C:\Users\<userid>\udk-debugger-trace.log.
- For Linux, the log file is in /home/<userid>/udk-debugger-trace.log.

Note that the log file is truncated to empty every time the Intel® UDK Debugger Tool starts up and tracing is turned on.

9.4 CPU exception information

The Intel® UDK Debugger Tool automatically shows the vector number and the error code whenever a CPU exception occurs in firmware.

If a CPU exception happens in firmware before the Intel® UDK Debugger Tool attaches, the Intel® UDK Debugger Tool automatically shows the exception information as soon as it attaches to the firmware. For the Linux version, the exception information is shown after sourcing the GDB script.

```
(gdb) c
Continuing.

Program received signal SIGTRAP, Trace/breakpoint trap.
0x0000000037f36fa1 in ?? ()
=> 0x0000000037f36fa1:  48 8b 04 25 00 00 ff ff mov
rax,QWORD PTR ds:0xffffffffffff0000
Target encounters an exception: Vector = 14, Error Code =
00000000
```

Figure 31 Output in GDB when a CPU exception happens in firmware

9.5 Disabling optimization

Compiler optimization switches are often used to reduce the size of the output file including the reduction of the debug information included in the output file.

To include more debug information in the output file, add compiler tags in the Components section of the DSC file.

For more information and an example of adding compiler tags, refer to section 2.2.5. Additional configuration requirements.

9.6 Improving debugger productivity

The debug tool can be more effective if these features are used:

- Set unresolved breakpoint
- Adjust the PcdDebugPropertyMask to enable CpuBreakpoint() on ASSERT() conditions.

9.7 Debugging SEC and PEI code

Most code for the SEC and PEI (pre-EFI initialization) phases executes from read-only memory.

The Intel® UDK Debugger Tool automatically uses a hardware breakpoint if it detects the address is within the read-only memory flash range. Currently, the Intel® UDK Debugger Tool assumes the range from 4GB-1MB to 4GB to be read-only.

9.8 Debugging DXE code

Some platform initialization firmware implementations execute SEC/PEI in 32-bit mode and execute DXE/SMM in 64-bit mode. When the Intel® UDK Debugger Tool detects a mode switch from 32-bit mode to 64-bit mode (or vice versa), WinDbg is automatically re-launched.

9.9 Debugging SMM code

The Intel® UDK Debugger Tool does not enable a timer interrupt in SMM to look for a break in the request from the host. Instead, an **smmentrybreak** command must be used to set a flag so that the next entry into SMM will force the target to break into the debugger.

Breakpoints can be set after the target enters SMM mode and debugging can continue. Refer to the discussion on WinDbg extension commands later in this section for a brief description of the **smmentrybreak** command.

When the target system stops at the SMM entry, the source code for SMM handlers and set software breakpoints may be opened. Basic debug operations may also be performed when the target system is stopped at the SMM.

SMM context is not visible after exiting SMM.

9.10 Debugging Boot Script code on S3 path

The Intel® UDK Debugger Tool does not enable a timer interrupt during executing Boot Script code on S3 path to look for a break in the request from the host. Instead, a **bootccriptentrybreak** command must be used to set a flag so that target will break into debugger tools before executing Boot script code.

Breakpoints can be set when target breaks before executing Boot Script code and debugging can continue. Refer to the discussion on WinDbg extension commands later in this section for a brief description of the **bootccriptentrybreak** command.

When the target system stops before executing boot script code, the source code of MdeModulePkg\Library\PiDxeS3BootScriptLib\BootScriptExecute.c could be opened and set software breakpoints for specific OpCode in `S3BootScriptExecute()`. Basic debug operations may also be performed from then on.

9.11 Debugging a standalone module loaded in a UEFI shell

The Intel® UDK Debugging Tool allows debugging of UEFI applications or UEFI drivers that are loaded and executed in the UEFI shell environment on the target, even if the target firmware does not include the source-level debug feature. The source code and debug symbol files of the firmware are not needed in order to use the Intel® UDK Debugging Tool.

For information about building a UEFI driver or UEFI application, refer to "Compiling a UEFI Driver using the Intel® UEFI Development Kit 2010", available at

http://www.intel.com/content/www/us/en/architecture-and-technology/unified-extensible-firmware-interface/uefi-driver-compiling-using-uefi-development-kit-guide.html.

This procedure also assumes that the source code of the UEFI driver or application resides on the host machine.

To debug in the shell environment, follow these general steps:

1. Make sure the target machine has available debug port (Serial Port or USB Debug Port)
2. Build DebugAgentDxe driver in SourceLevelDebugPkg. The build command will vary depending on the debug port type:
   - Debug Agent for Serial Port (x64):

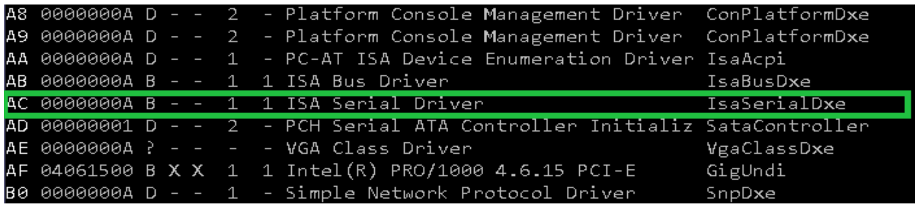
     build -p SourceLevelDebugPkg\SourceLevelDebugPkg.dsc -m SourceLevelDebugPkg/DebugAgentDxe/DebugAgentDxe.inf -a X64
   - Debug Agent for USB Debug Port (x64):

     build -p SourceLevelDebugPkg\SourceLevelDebugPkg.dsc -m SourceLevelDebugPkg/DebugAgentDxe/DebugAgentDxe.inf -a X64 -D SOURCE_DEBUG_USE_USB
3. Copy the Debug Agent (**`DebugAgentDxe.efi`**) to a USB drive. For x64, the file is in the **`Build\SourceLevelDebugPkg\DEBUG_VS2008\X64\`** directory
4. On the host system, build the UEFI application or UEFI driver to be debugged and copy the executable output file (such as `example.efi`) to the USB memory stick.
5. Remove the USB memory stick from the host and plug it into the target system.
6. Power up the target machine and wait for the target to boot to the UEFI shell.
7. Connect the debug cable between the target and host machines.
8. Start Debugging feature on target machine by following steps:

a) If debug port is Serial Port,

1. Get handle number of IsaSerialDxe:

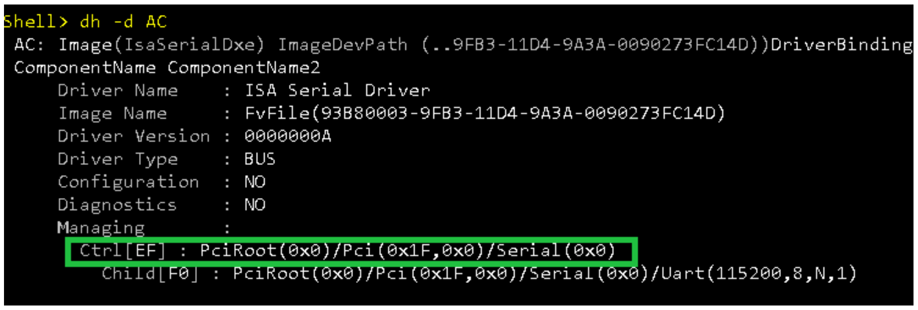
Shell> Drivers



```
A8 0000000A D - -  2  - Platform Console Management Driver  ConPlatformDxe
A9 0000000A D - -  2  - Platform Console Management Driver  ConPlatformDxe
AA 0000000A D - -  1  - PC-AT ISA Device Enumeration Driver IsaAcpi
AB 0000000A B - -  1  1 ISA Bus Driver                      IsaBusDxe
AC 0000000A B - -  1  1 ISA Serial Driver                   IsaSerialDxe
AD 00000001 D - -  2  - PCH Serial ATA Controller Initializ SataController
AE 0000000A ? - -  -  - VGA Class Driver                    VgaClassDxe
AF 04061500 B X X  1  1 Intel(R) PRO/1000 4.6.15 PCI-E      GigUndi
B0 0000000A D - -  1  - Simple Network Protocol Driver      SnpDxe
```

2. Find the handle number of serial port managed by IsaSerialDxe by IsaSerialDxe 's handle number:

Shell> dh -d AC



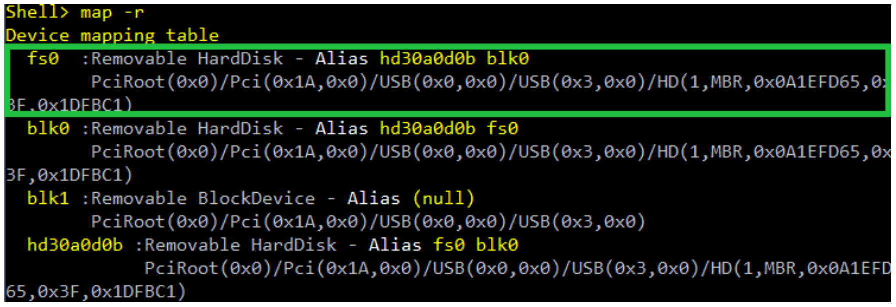
```
Shell> dh -d AC
 AC: Image(IsaSerialDxe) ImageDevPath (..9FB3-11D4-9A3A-0090273FC14D))DriverBinding
 ComponentName ComponentName2
     Driver Name     : ISA Serial Driver
     Image Name      : FvFile(93B80003-9FB3-11D4-9A3A-0090273FC14D)
     Driver Version  : 0000000A
     Driver Type     : BUS
     Configuration   : NO
     Diagnostics     : NO
     Managing        :
       Ctrl[EF] : PciRoot(0x0)/Pci(0x1F,0x0)/Serial(0x0)
         Child[F0] : PciRoot(0x0)/Pci(0x1F,0x0)/Serial(0x0)/Uart(115200,8,N,1)
```

3. Disconnect the controller managed by IsaSerialDxe by serial port's handle number:

Shell> disconnect EF

4. Load DebugAgentDxe.efi from the USB memory stick

Shell> map -r



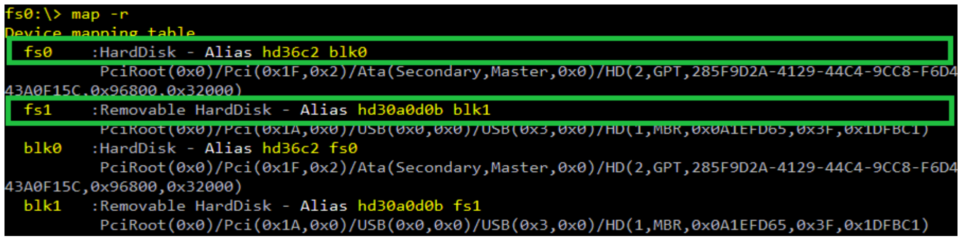
```
Shell> map -r
Device mapping table
  fs0  :Removable HardDisk - Alias hd30a0d0b blk0
        PciRoot(0x0)/Pci(0x1A,0x0)/USB(0x0,0x0)/USB(0x3,0x0)/HD(1,MBR,0x0A1EFD65,0
3F,0x1DFBC1)
  blk0 :Removable HardDisk - Alias hd30a0d0b fs0
        PciRoot(0x0)/Pci(0x1A,0x0)/USB(0x0,0x0)/USB(0x3,0x0)/HD(1,MBR,0x0A1EFD65,0x
3F,0x1DFBC1)
  blk1 :Removable BlockDevice - Alias (null)
        PciRoot(0x0)/Pci(0x1A,0x0)/USB(0x0,0x0)/USB(0x3,0x0)
  hd30a0d0b :Removable HardDisk - Alias fs0 blk0
             PciRoot(0x0)/Pci(0x1A,0x0)/USB(0x0,0x0)/USB(0x3,0x0)/HD(1,MBR,0x0A1EFD
65,0x3F,0x1DFBC1)
```

Shell> fs0:

fs0:\> Load –nc DebugAgentDxe.efi

b) If debug port is USB Debug Port, copy DebugAgentDxe.efi and the debugged driver's *.efi* file into the hard disk

```
Shell> map -r
```



```
fs0:\> map -r
Device mapping table
  fs0     :HardDisk - Alias hd36c2 blk0
           PciRoot(0x0)/Pci(0x1F,0x2)/Ata(Secondary,Master,0x0)/HD(2,GPT,285F9D2A-4129-44C4-9CC8-F6D4
43A0F15C,0x96800,0x32000)
  fs1     :Removable HardDisk - Alias hd30a0d0b blk1
           PciRoot(0x0)/Pci(0x1A,0x0)/USB(0x0,0x0)/USB(0x3,0x0)/HD(1,MBR,0x0A1EFD65,0x3F,0x1DFBC1)
  blk0    :HardDisk - Alias hd36c2 fs0
           PciRoot(0x0)/Pci(0x1F,0x2)/Ata(Secondary,Master,0x0)/HD(2,GPT,285F9D2A-4129-44C4-9CC8-F6D4
43A0F15C,0x96800,0x32000)
  blk1    :Removable HardDisk - Alias hd30a0d0b fs1
           PciRoot(0x0)/Pci(0x1A,0x0)/USB(0x0,0x0)/USB(0x3,0x0)/HD(1,MBR,0x0A1EFD65,0x3F,0x1DFBC1)
```

```
Shell> copy fs1:\DebugAgentDxe.efi fs1:\example.efi fs0:
Shell> fs0:
fs0:\> Load DebugAgentDxe.efi
```

9. On the host machine, launch the Intel® UDK Debugger Tool to connect the TARGET.
10. On the host, set an unresolved breakpoint at the entry point for the driver or application and let the TARGET go:
    - **WinDbg:** Issue the **go** command
    - **Linux/GDB:** Enter the **c** command
11. On the target machine, load and execute the driver's *.efi* file from the USB memory stick or the hard disk.

On the host, the debugger tool will stop at the unresolved breakpoint set in Step 6 (above). After that, performing basic debug operations can begin with the debug session for the application or driver loaded on the target machine.

9.12 Intelligent symbol path searching

Sometimes the location of the symbol files is moved. Change [Features]/SymbolPath setting to identify multiple directory paths (semicolon ';' as the separator), where the symbol files can be searched. Intel® UDK Debugger Tool gets the symbol file path stored in the PE file. When it cannot locate the symbol file, an intelligent symbol path searching method is used to find the correct symbol file path. That is, it attempts to locate a file by prefixing each directory path specified by the [Features]/SymbolPath setting to the original symbol file path read from the PE file. Alternatively, if it cannot locate the file, it iteratively strips parts from the head of the original symbol file path until it locates the symbol file.
If it cannot locate the symbol file, the symbol file won't be loaded. For example:

The symbol file path stored in the PE file is: J:\BuildRoot\MdeModulePkg\Application\HelloWorld\HelloWorld.pdb and it is moved to C:\Users\foo\HelloWorld\HelloWorld.pdb. With the following configuration setting:

```
[Features]
SymbolPath = C:\Users\foo
```

The following paths are tried until the symbol file is successfully located:

1) Original symbol file path:
J:\BuildRoot\MdeModulePkg\Application\HelloWorld\HelloWorld.pdb

2) Combination of [Features]/SymbolPath and the original symbol file path:
C:\Users\fooJ:\BuildRoot\MdeModulePkg\Application\HelloWorld\HelloWorld.pdb

3) With "J:" stripped:
C:\Users\foo\BuildRoot\MdeModulePkg\Application\HelloWorld\HelloWorld.pdb

4) With "\BuildRoot" stripped:
C:\Users\foo\MdeModulePkg\Application\HelloWorld\HelloWorld.pdb

5) With "\MdeModulePkg" stripped:
C:\Users\foo\Application\HelloWorld\HelloWorld.pdb

6) With "\Application" stripped: C:\Users\foo\HelloWorld\HelloWorld.pdb

9.13 Source code not available

In some cases, the source code and debug symbol files of the firmware may not be available. If so, only the driver or application compiled from the source code can be debugged.

When the source code and symbol files are not available, debug BIOS firmware only at the assembly code level.

9.14 Restart the debug session

CAUTION: Powering down the target machine while the Intel® UDK Debugger Tool is running on the host machine is not supported and may produce unpredictable results. Make sure to close the debugging session on the host machine before powering down the target system.

- Windows/WinDbg
  - Use the .reboot command to reset the target machine and restart the debug session.
- Linux/GDB
  - Use the resettarget GDB extension command to reboot the target machine and restart a debug session.

9.14.1 Shifting to a different architecture mode (32-bit vs. 64-bit)

- Windows/WinDbg:
  - **Automatic relaunch with a change in architecture.**
    In some cases, the **.reboot** command is issued in 64-bit mode but the SEC/PEI is in 32-bit mode. If so, WinDbg will automatically relaunch in order to continue debugging the 32-bit SEC/PEI code.
- Linux/GDB:
  - Already supports changes in architecture. GDB supports changes in architecture and does not need to be relaunched when a mode changes between 32-bit and 64-bit.

NOTE: Do not set unresolved breakpoints in code that runs in a different architecture mode, e.g., setting an unresolved breakpoint in a DXE module when the TARGET is stopped in PEI phase. It may cause unpredicted results.

Appendix A Additional Information

A.1 TERMS

This user manual uses the following acronyms and terms.

AP

Additional processors

BAR

Base address register

BSP

Boot strap processor

COM

Communication

CS

Code segment

CSM

Compatibility support module

CPU

Central processing unit

DSC

The file extension for files containing information used during the FDF build process.

Debugger package

A source-level debug package provided by Intel and required during the BIOS build process. When building the target firmware image, the source-level debugger package must be included in each build in order to use the Intel® UDK Debugger Tool to debug the target system. When included in the firmware build, the target system has debug functionality ("target debugger").

Debug solution

The combination of tools and packages that provide debug capability on both the host and target systems. This includes the Intel® UDK Debugger Tool, the operating system (OS)-specific debug tool (on the host system), and the source-level debug package (on the target system).

DXE

Driver execution. The DXE phase initializes the rest of the system hardware.

ECP

Intel® UEFI Development Kit 2010 (Intel® UDK2010) compatibility platforms

EFI

Extensible Firmware Interface

EHCI

Extended (extensible) host controller interface

eXdi

A process that extends functionality to Microsoft WinDbg or other Microsoft applications.

FDF

Firmware device file

FIFO

First in first out

GDB

GNU Project Debugger*

Host debugger:

The debug functionality on the host system. The host debugger is a combination of the Intel® UDK Debugger Tool and the OS-specific debug tool.

IDT

Interrupt description table

Intel® UDK2010

Intel's UEFI development kit.

Intel® UDK Debugger Tool

A debugger tool that adds functionality to an OS-specific debug tool. For example, the Intel® UDK Debugger Tool adds functionality to Microsoft Windows Debug Tool* (WinDbg) as well as to the GNU Project debugger* (GDB) for Linux platforms.

IP

Instruction pointer

MP

Multiple processors

OS

Operating system

PCD

Platform configuration database

PCI

Peripheral component interconnect

PDB

Platform database—the file extension of the file containing source-level debug information from Microsoft compilers. (Linux compilers use a different extension.)

PE

PE/COFF execution

PE/COFF

Portable executable and object file format

PEI

Pre-EFI initialization. The PEI phase finishes initializing the CPU, makes permanent RAM (such as normal DRAM) available. It then determines the boot mode (such as normal boot, ACPI S3 resume from sleep, or ACPI S4 resume from hibernation).

PEIM

Pre-EFI initialization module

RAM

Random access memory

SEC

Security. The security (SEC) phase brings the system out of CPU reset and makes temporary RAM available for the stack and for data storage.

SecCore

During the SEC (security) phase of execution, the SecCore are the common functions across all platform implementations of the Intel® UDK 2010 based firmware.

SMI

System management interrupt

SMM

System management mode

Target debugger

The debugger functionality on the target system. This functionality is part of a BIOS image that has been built with the Intel-provided source-level debugger package.

TE

Terse execution. This image format is a reduction in size of PE (PE/COFF execution). Note that the PE image format has a large header portion that the TE image format trims significantly.

UDK

UEFI Development Kit

UEFI

Unified Extensible Firmware Interface

A.2 Conventions used in this document

This document uses the following conventions for code samples and typographic differentiation.

A.2.1 Nomenclature of CPU architectures

This user manual refers to the following architectures:

- Intel IA32 refers to Intel's 32-bit processor architecture.
- Intel x64 refers to Intel's 64-bit superset of IA32.
- Intel IA-64 refers to the Intel® Itanium® Platform Architecture (Intel IPF).

A.2.2 Pseudo-code conventions

Pseudo code is presented to describe algorithms in a more concise form. None of the algorithms in this document are intended to be compiled directly. The code is presented
at a level corresponding to the surrounding text.

In describing variables, a list is an *unordered* collection of homogeneous objects. A queue is an *ordered* list of homogeneous objects. Unless otherwise noted, the ordering is assumed to be first-in-first-out (FIFO).

Pseudo code is presented in a C-like format, using C conventions where appropriate.
The coding style, particularly the indentation style, is used for readability and does not necessarily comply with an implementation of the UEFI specification.

A.2.3 Typographic conventions

This document uses the typographic and illustrative conventions described below:

Plain text	The normal text typeface is used for the vast majority of the descriptive text in a specification.
Plain text (blue)	In the electronic version of this specification, any plain text, under-lined and in blue, indicates an active link to the cross-reference.
Bold	In text, a Bold typeface identifies a processor register name. In other instances, a Bold typeface is used as a running head within a paragraph or to emphasize a critical term.
Italic	In text, an Italic typeface can be used as emphasis to introduce a new term or to indicate the title of documentation such as a user's manual or name of a specification.
Monospace	Computer code, example code segments, pseudo code, and all prototype code segments use a **BOLD Monospace** typeface with a dark red color. These code listings normally appear in one or more separate paragraphs, though words or segments can also be embedded in a normal text paragraph.
Italic Monospace	In code or in text, words in ***Italic Monospace*** indicate placeholder names for variable information (i.e., arguments) that must be supplied.

A.2.4 Other conventions

This user manual also uses the following convention for Linux examples:

`foo@foo:~$`	A user-defined command prompt for Linux-based command lines used in the examples in this manual.

A.3 For more information

UEFI Specification:

Information about UEFI device types and status codes can be found in the *Unified Extensible Firmware Interface*, version 2.3.1 or later, and at the UEFI Forum , www.uefi.org. A summary of UEFI services and GUIDs can be found in the Doxygen-generated help documents for the MdePkg in the Intel® UDK 2010 releases.

tianocore.org:

The Intel® UDK 2010 source files and specifications are available at www.tianocore.org (http://tianocore.sourceforge.net).

UEFI Driver Writers Guide:

Refer to the *UEFI Driver Writer's Guide* for key descriptions of how to implement UEFI requirements as well as recommendations for writing drivers. This guide is now available at www.tianocore.org (http://tianocore.sourceforge.net).

UEFI Development Kit 2010 (UDK2010):

This open-source kit provides the modern, feature-rich, cross-platform firmware development environment for the UEFI and PI specifications. The Intel® UDK2010 is a stable release of this open-source kit and has been validated on a variety of Intel platforms, operating systems, and application software. It is available for download at www.tianocore.org (http://tianocore.sourceforge.net).