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UEFI & EDK II Training

EDK II Modules: Libraries, Drivers & Applications

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LESSON OBJECTIVE

- What is a EDK II Module
- Use EDK II libraries to write UEFI apps/drivers
- How to Define a UEFI application
- Differences between UEFI App / Drivers INF file

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EDK II MODULES OVERVIEW

What are EDK II Modules

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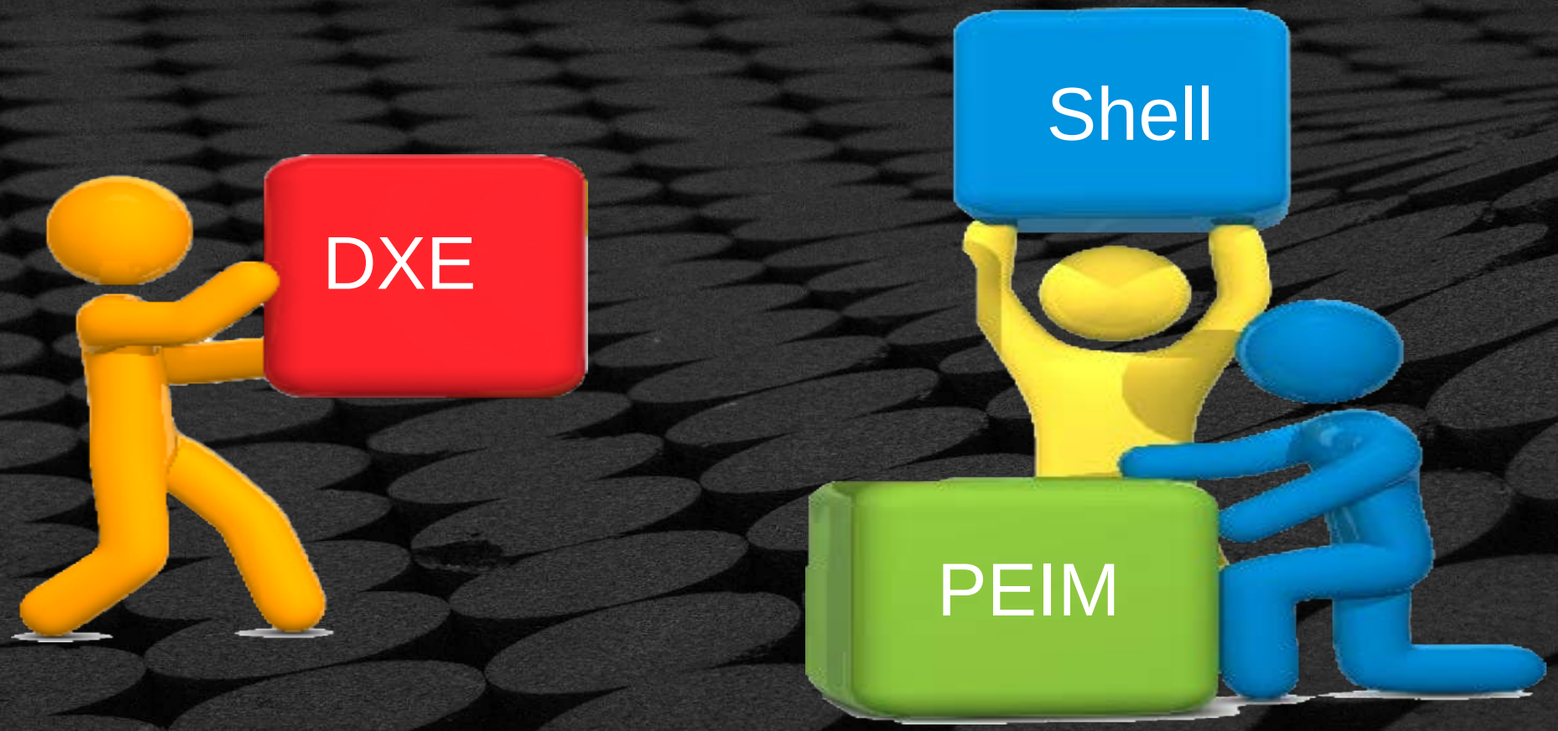
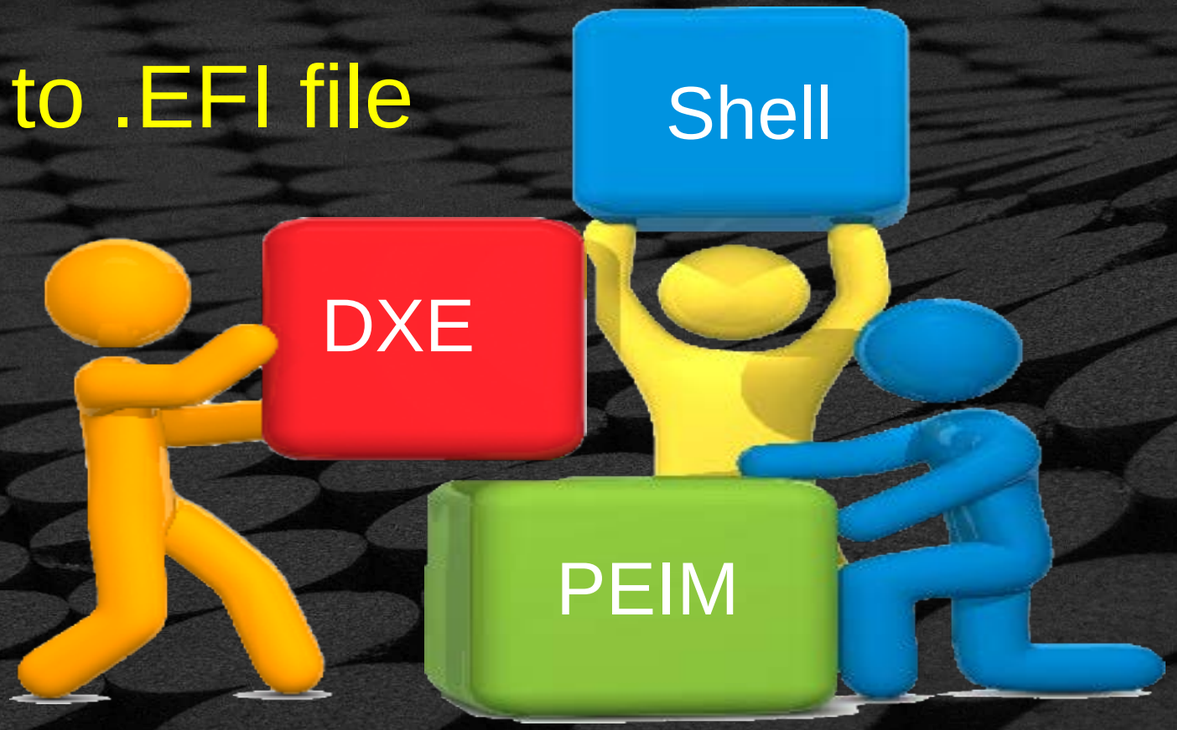
MODULES



MODULES

Smallest separate object compiled in EDK II

Compiles to .EFI file



UEFI/DXE Driver

PEIM

UEFI App.

Library

Modules: Building blocks of EDK II

MODULE TYPES

Most Used Module Types

PEI_CORE

UEFI_APPLICATION

DXE_CORE

BASE

DXE_RUNTIME_DRIVER

PEIM

UEFI_DRIVER

DXE_DRIVER

<ModuleTypes> ::= <ModuleType> [<Space> <ModuleType>]

Module Source Contents - minimum file

MODULE_TYPE	Example Source Files
UEFI Application	
UEFI Driver	
DXE Driver	
UEFI Driver - *Library*	

Module Source Contents - minimum file

MODULE_TYPE		Example Source Files
UEFI Application	–	Foo.c, Foo.inf
UEFI Driver	–	FooDriver.c, FooDriver.h, FooDriver.vfr, FooDriver.uni, FooDriver.inf
DXE Driver	–	FooDxe.c, FooDxe.h, FooDxe.inf
UEFI Driver - *Library*	–	FooLib.c., FooLib.h, FooLib.inf w/ LIBRARY_CLASS= FooLib | …

Module Source Contents - minimum file

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COMPLEXITY - Number of source files dependent

Module Source Contents - minimum file

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COMPLEXITY - Number of source files dependent

.INF file - One file is required per module

Module Source Contents - minimum file

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COMPLEXITY - Number of source files dependent

.INF file - One file is required per module

.EFI file - Sources compiled to a single .EFI file

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EDK II LIBRARY MODULES

Library Class

```
[LibraryClasses.common]
  <LibraryClassName>|<LibraryInstancePathToInf/Name.inf>
  DebugLib|MdePkg/Library/BaseDebugLibNull/BaseDebugLibNull.inf
```

Library Class

```
[LibraryClasses.common]
  <LibraryClassName>|<LibraryInstancePathToInf/Name.inf>
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```

Name | **Implementation (1)**

Library Class

```
[LibraryClasses.common]
  <LibraryClassName>|<LibraryInstancePathToInf/Name.inf>
  DebugLib|MdePkg/Library/BaseDebugLibNull/BaseDebugLibNull.inf
```

Name | **Implementation (2)**

Library Class

```
[LibraryClasses.common]
  <LibraryClassName>|<LibraryInstancePathToInf/Name.inf>
  DebugLib|MdePkg/Library/BaseDebugLibNull/BaseDebugLibNull.inf
```

Name | **Implementation (3)**

Library Class

```
[LibraryClasses.common]
  <LibraryClassName>|<LibraryInstancePathToInf/Name.inf>
  DebugLib|MdePkg/Library/BaseDebugLibNull/BaseDebugLibNull.inf
```

Name | **Implementation (3)**

Consistent set of interfaces

Library Class

```
[LibraryClasses.common]
  <LibraryClassName>|<LibraryInstancePathToInf/Name.inf>
  DebugLib|MdePkg/Library/BaseDebugLibNull/BaseDebugLibNull.inf
```

Name | **Implementation (3)**

Consistent set of interfaces

Does not describe implementation of the interfaces

“NULL” Library Class

Syntax

```
Pkg/MyModule/MyModule.inf {
 <LibraryClasses>
     NULL|Pkg/Library/LibName/LibName.inf
     NULL|Pkg/Library/LibName2/LibName2.inf
}
```

Shell application example:

```
ShellPkg/Application/Shell/Shell.inf {
    <LibraryClasses>
      NULL|ShellPkg/Library/UefiShellDriver1CommandsLib/UefiShellDriver1CommandsLib.inf
      NULL|ShellPkg/Library/UefiShellNetwork1CommandsLib/UefiShellNetwork1CommandsLib.inf
          . . .
}
```

“NULL” Library Class

Constructors

Syntax

```
Pkg/MyModule/MyModule.inf {
 <LibraryClasses>
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```

“NULL” Library Class

Constructors

Special Cases

Syntax

```
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“NULL” Library Class

Constructors

Special Cases

NOT “. . . LibNull” instance

Syntax

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```

“NULL” Library Class

Constructors

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NOT “. . . LibNull” instance

Syntax

```
Pkg/MyModule/MyModule.inf {
 <LibraryClasses>
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}
```

Open Source Example

DxeCrc32GuidedSectionExtractLib
ShellPkg as used with Profiles

Shell application example:

```
ShellPkg/Application/Shell/Shell.inf {
    <LibraryClasses>
      NULL|ShellPkg/Library/UefiShellDriver1CommandsLib/UefiShellDriver1CommandsLib.inf
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          . . .
}
```

Locating Library Classes

Library based upon

1. Industry specs (UEFI, etc.)
   `MdePkg/MdeModulePkg`
2. Intel's framework[1] specs
   `IntelFrameworkPkg/IntelFrameworkModulePkg`

[1] Intel® Platform Innovation Framework for UEFI

Locating Library Classes

Library based upon

1. Industry specs (UEFI, etc.)
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Use the package help files (.**CHM**) to find a library or function

Example: **`MdePkg.chm`**

[1] Intel® Platform Innovation Framework for UEFI

Locating Library Classes

Library based upon

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   `MdePkg/MdeModulePkg`
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   `IntelFrameworkPkg/IntelFrameworkModulePkg`

Use the package help files (.**CHM**) to find a library or function

Example: **`MdePkg.chm`**

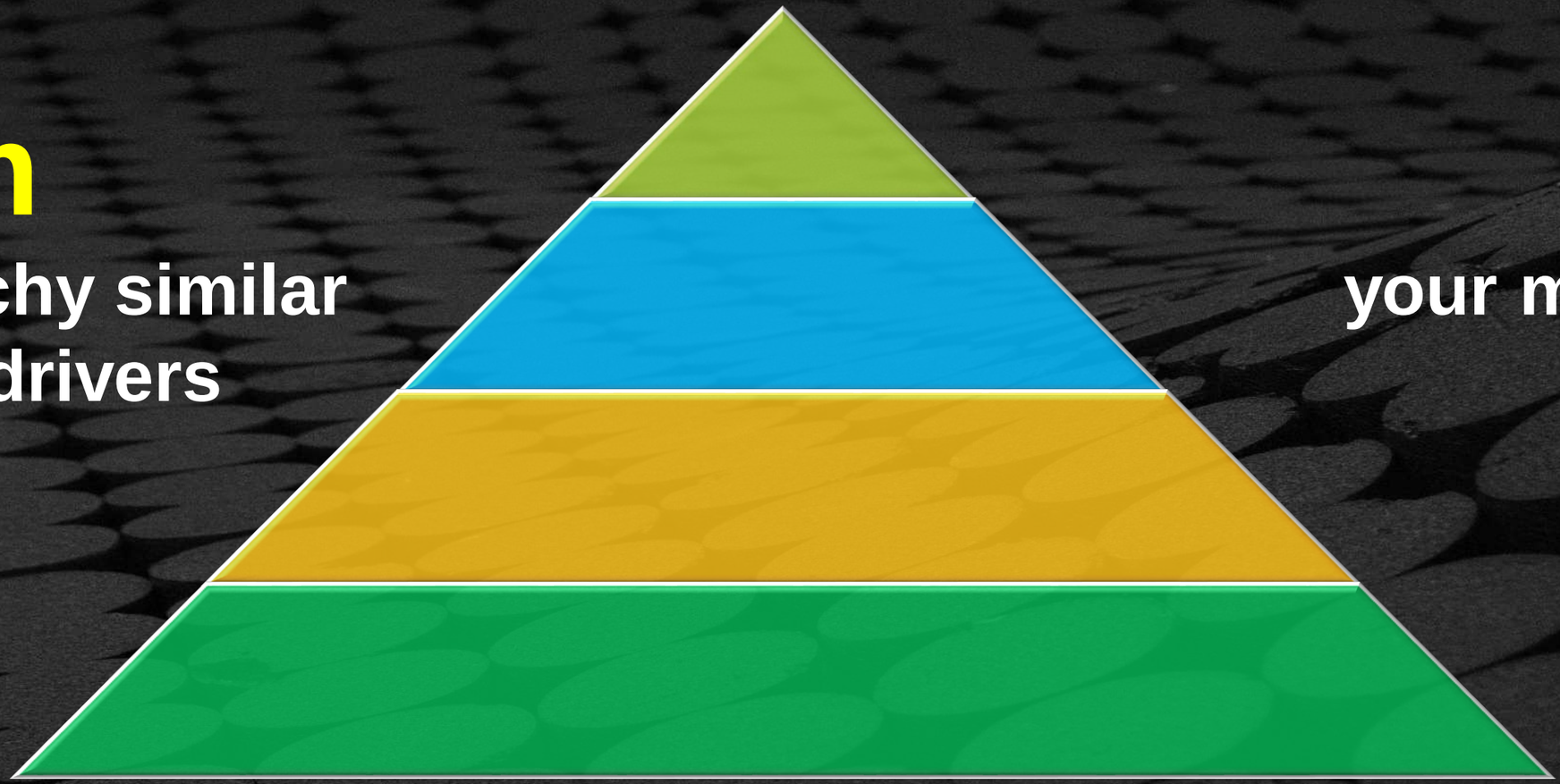
Search WorkSpace (.INF) **`"LIBRARY_CLASS"`**

[1] Intel® Platform Innovation Framework for UEFI

Library Instance Hierarchy

Form

a hierarchy similar to UEFI drivers



Link

your module to another

Library Instance Hierarchy

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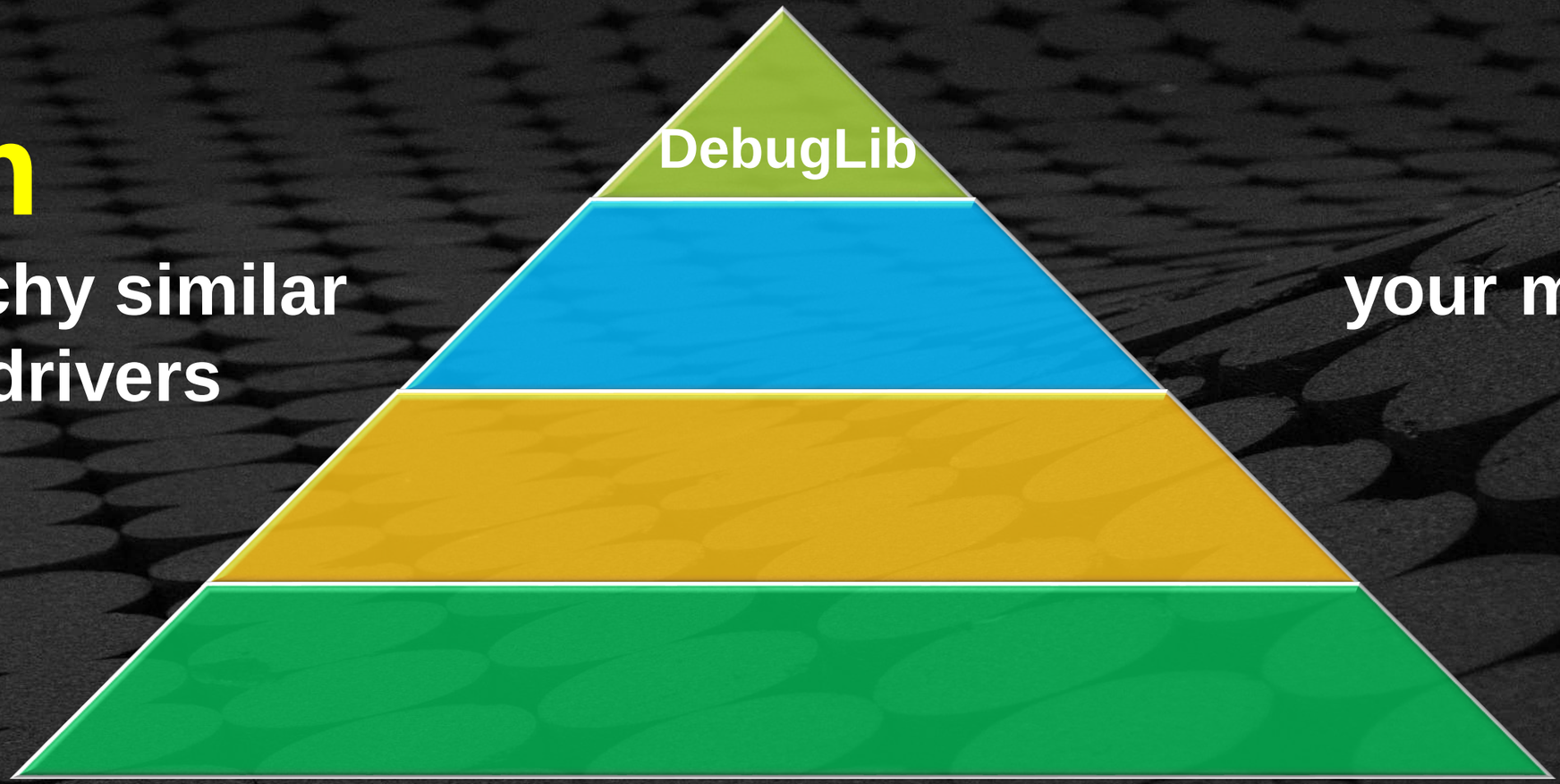

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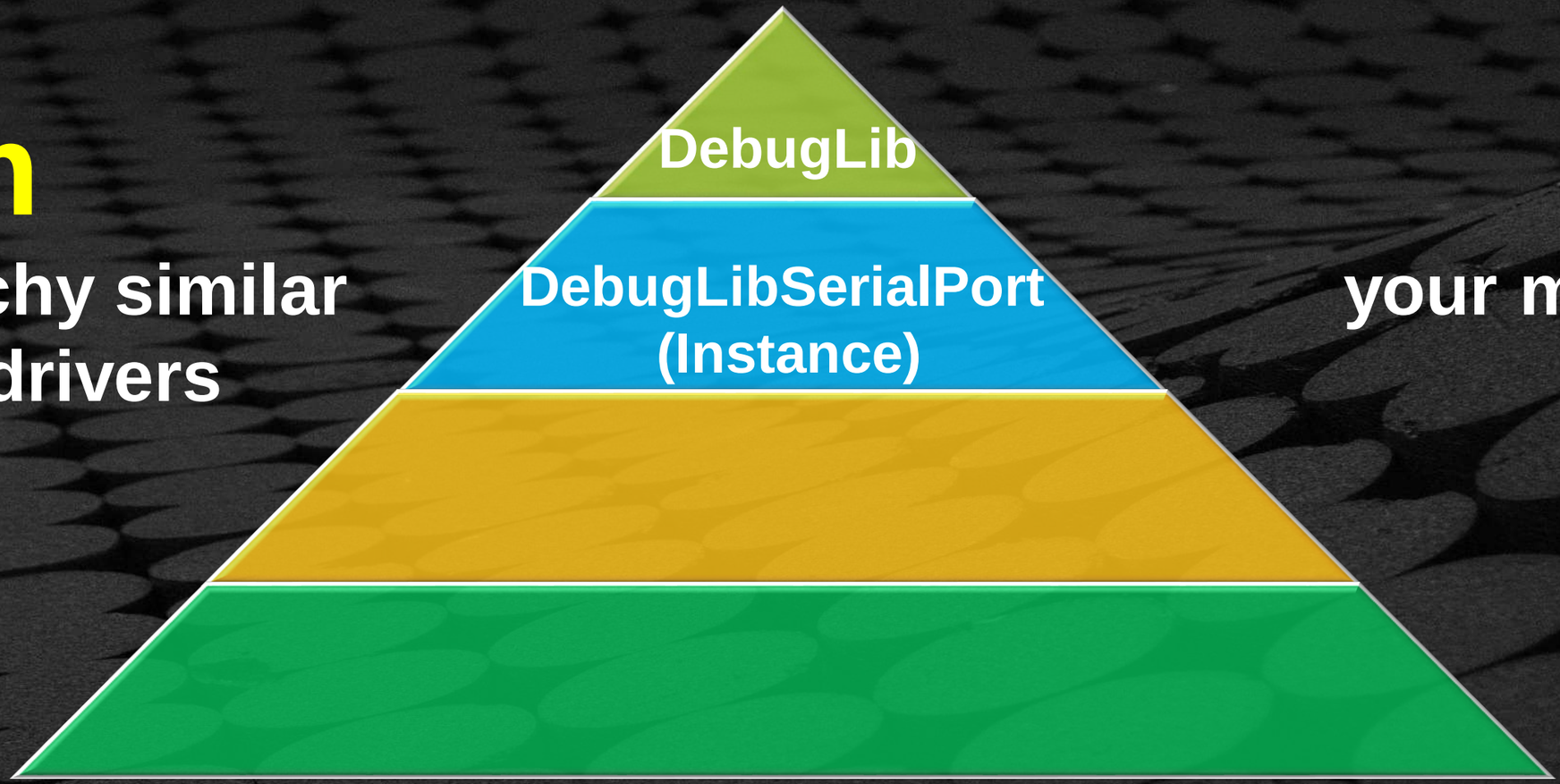

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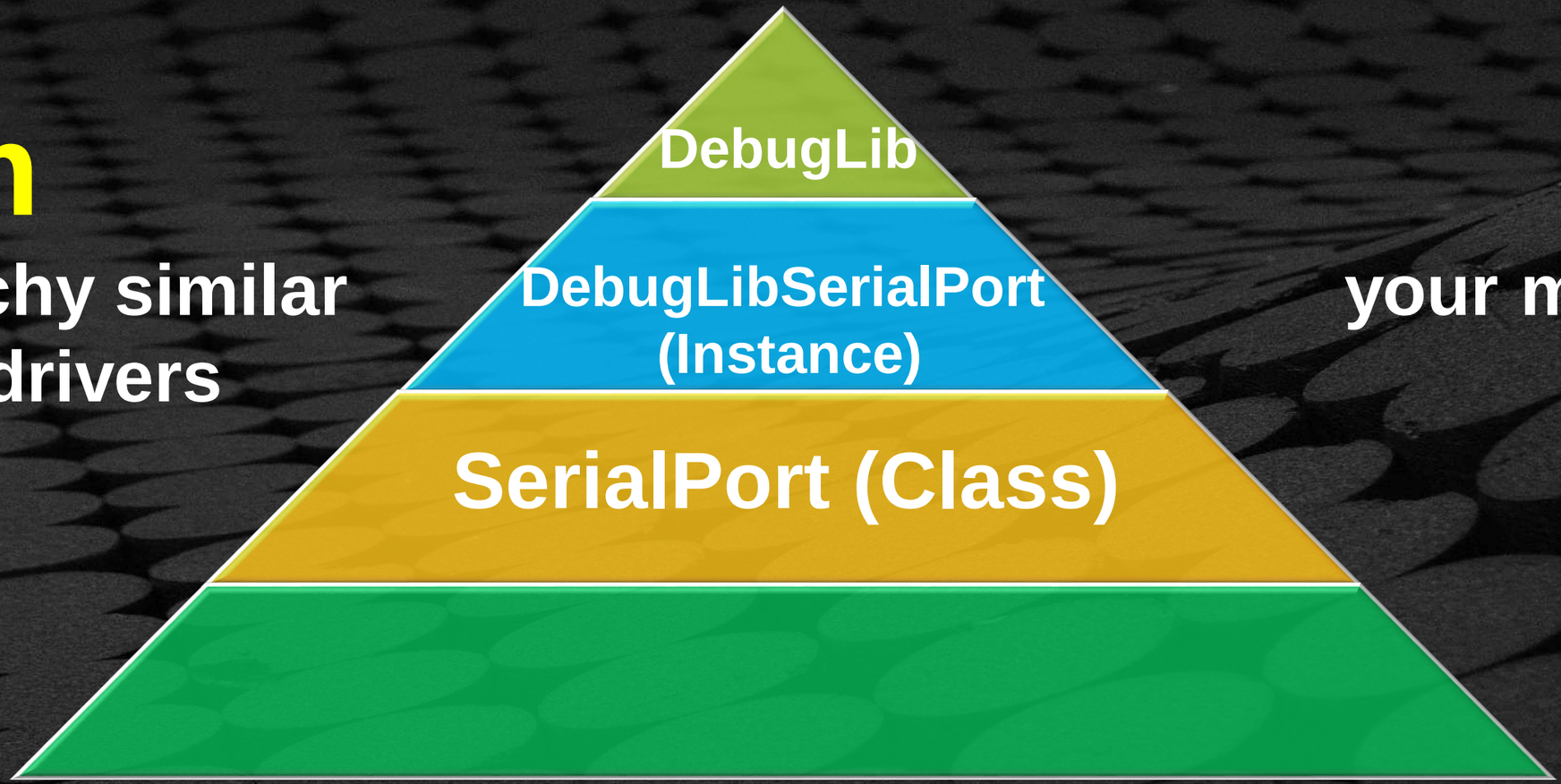

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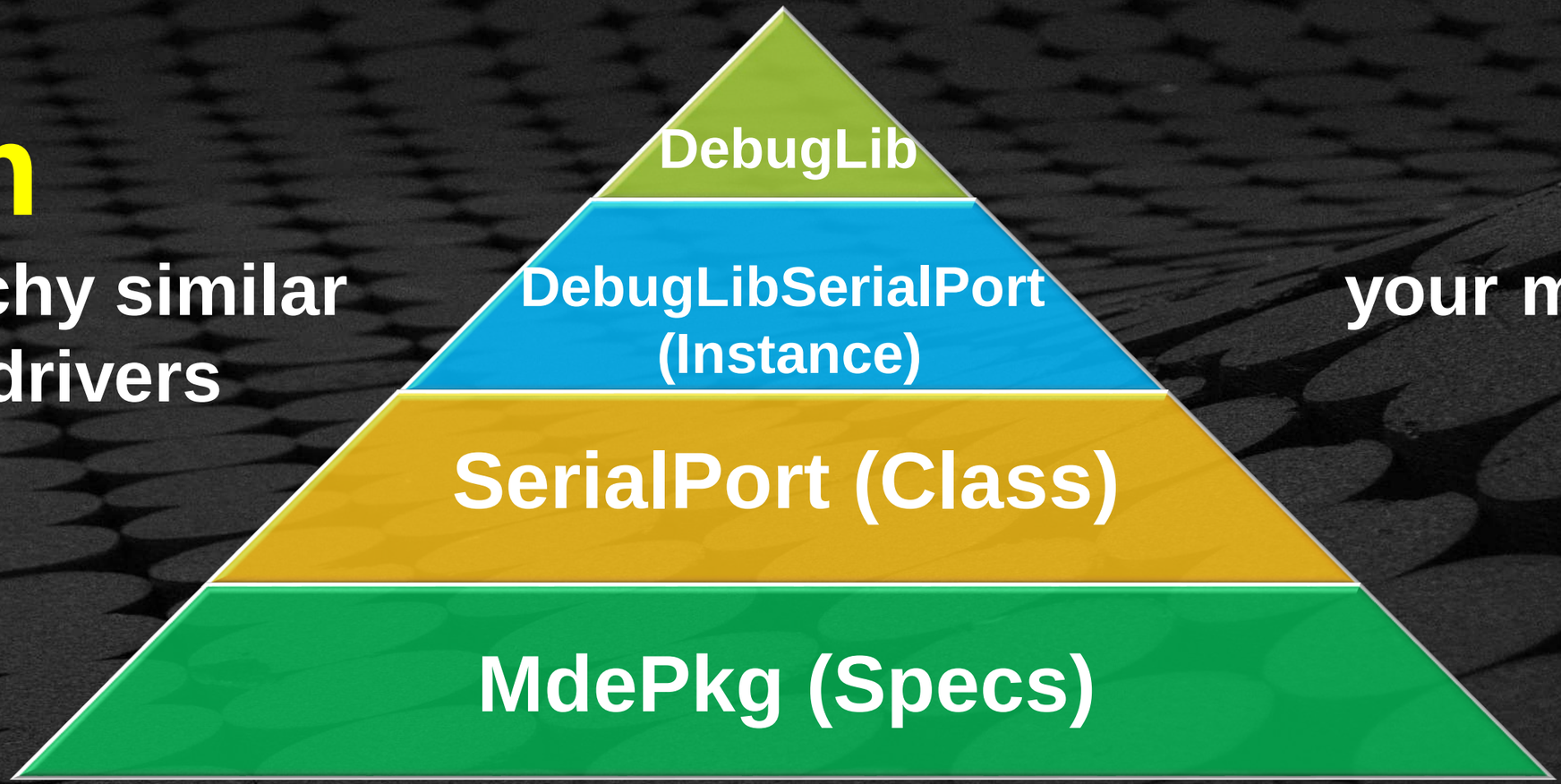

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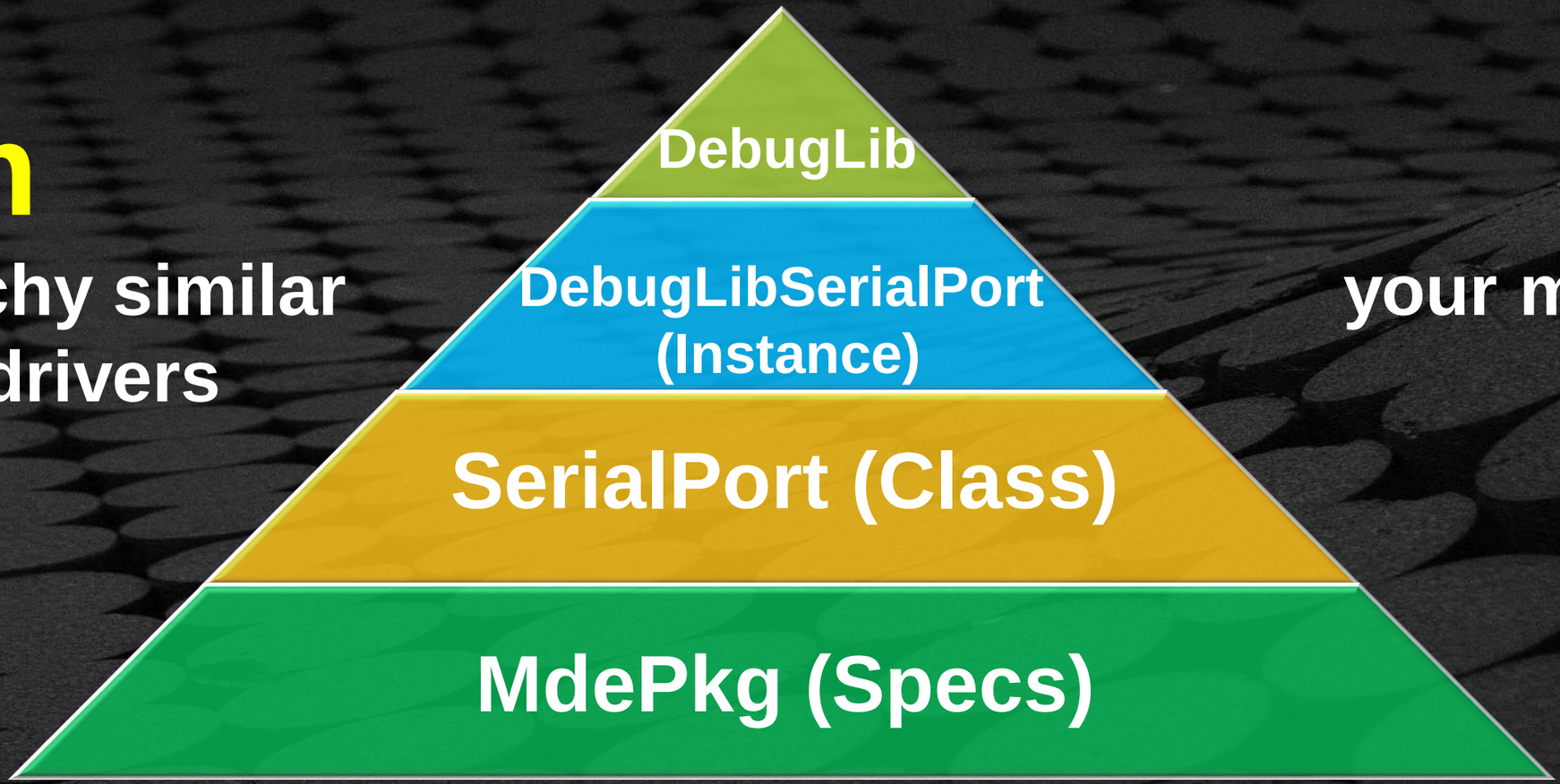


Link

your module to another

Build error : Instance of Library class [*Foo…Lib*] is not found ….
Consumed by module [*My Module.inf*]

Commonly Used Base Library Classes

Commonly Used Base Library Classes

```
BaseLib      DebugLib
      UefiLib
  UefiApplicationEntryPoint
```

Commonly Used Base Library Classes

BaseLib

DebugLib

UefiLib

BaseMemoryLib

UefiApplicationEntryPoint

PeiCoreEntryPoint

DxeCoreEntryPoint

PrintLib

UefiBootServicesTableLib

UefiScsiLib

DevicePathLib

PeimEntryPoint

Commonly Used Base Library Classes

BaseLib

DebugLib

SalLib

CpuLib

UefiLib

BaseMemoryLib

UefiApplicationEntryPoint

UefiUsbLib

UefiDriverEntryPoint

MemoryAllocationLib

PeiCoreEntryPoint

DxeCoreEntryPoint

IoLib

PrintLib

UefiBootServicesTableLib

UefiRuntimeLib

PciLib

UefiScsiLib

DevicePathLib

PeimEntryPoint

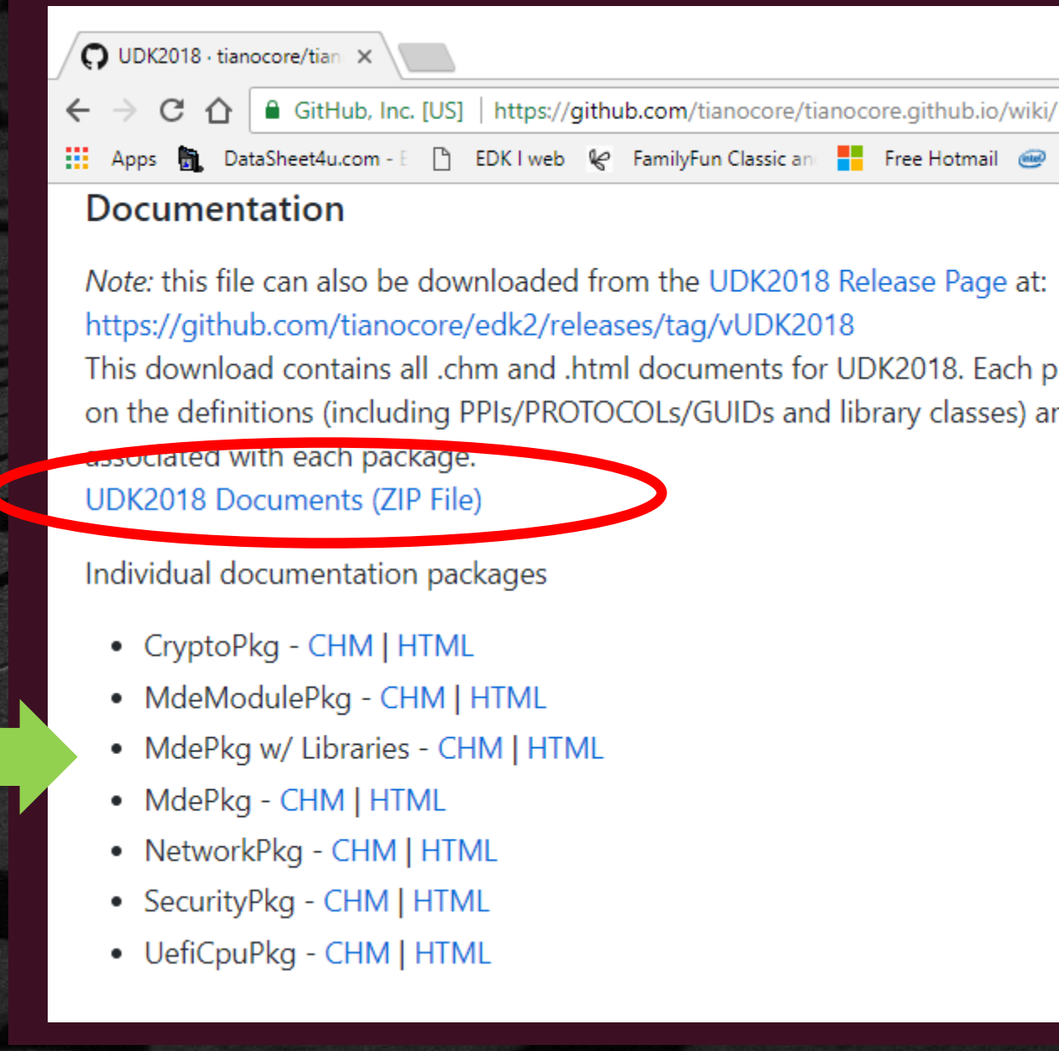
Commonly Used Base Library Classes

BaseLib
DebugLib
SalLib
CpuLib
UefiLib
BaseMemoryLib
UefiApplicationEntryPoint
UefiUsbLib
DxeServicesLib
SynchronizationLib
UefiDriverEntryPoint
MemoryAllocationLib
PeiCoreEntryPoint
DxeCoreEntryPoint
UefiRuntimeServicesTableLib
IoLib
PrintLib
UefiBootServicesTableLib
UefiRuntimeLib
PciSegmentLib
PciLib
UefiScsiLib
DevicePathLib
PciExpressLib
PeiServicesLib
PeimEntryPoint

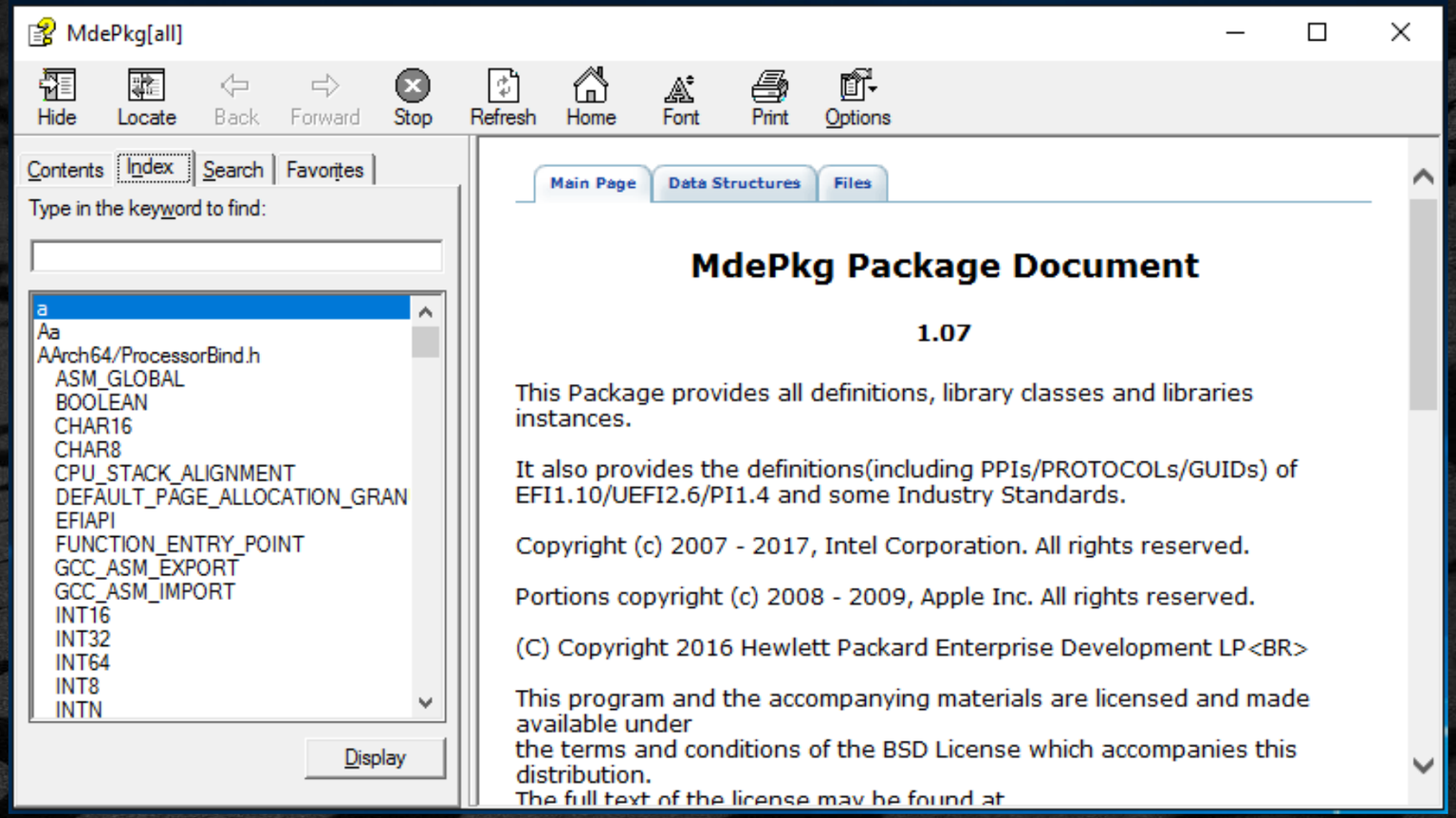
MdePkg Library .CHM file Location

tianocore.org UDK2018 documentation on

- Latest UDK Release
- UDK2018



Library Navigation Demonstration

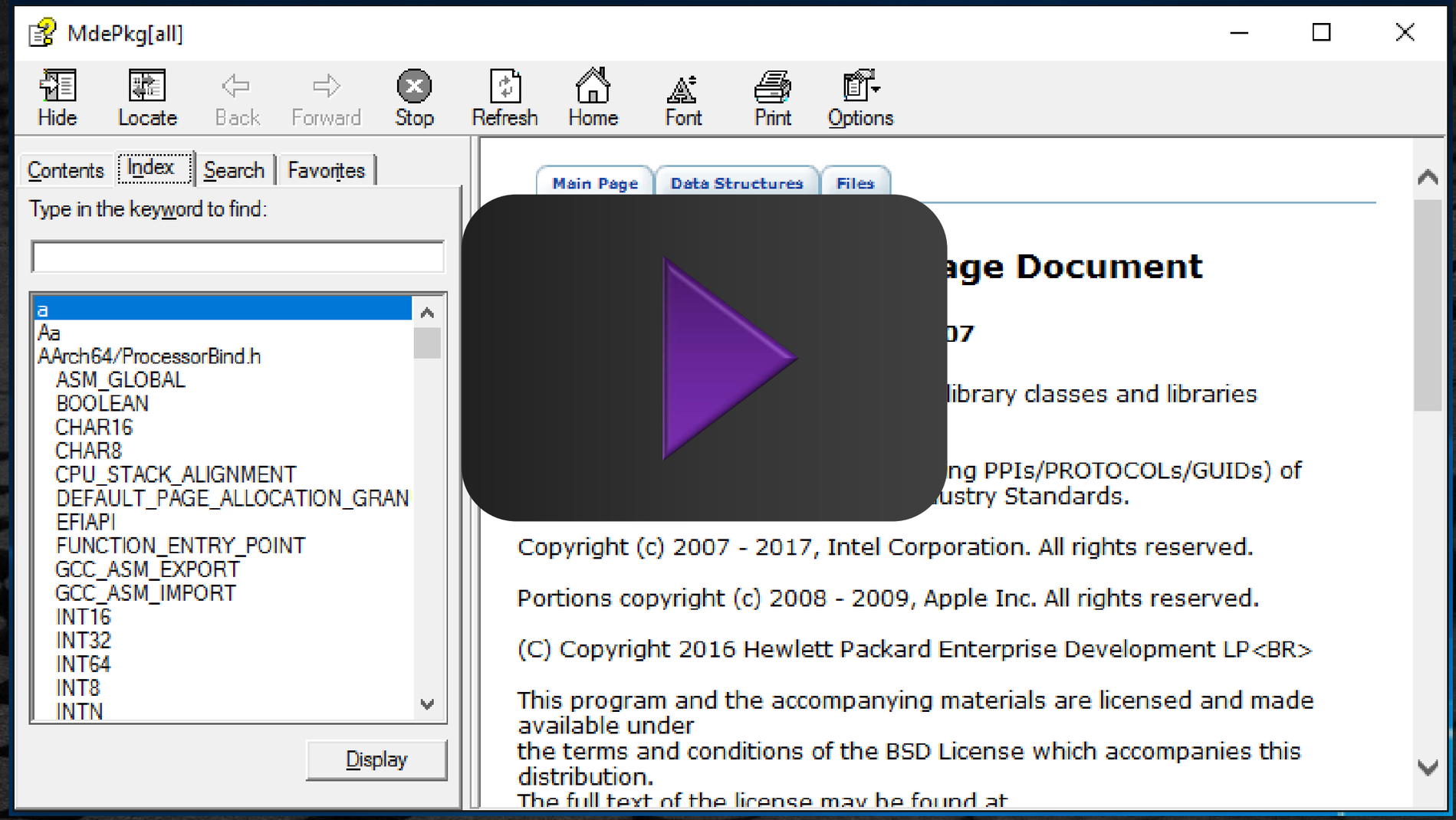


Open file: /FW/Documentation/”MdePkg Document With LibrariesMdePkg.chm”

NOTE: Install a CHM Viewer for Ubuntu

```
bash$ sudo aptitude install kchmviewer
```

Library Navigation Demonstration



https://youtu.be/s8Zw1w1iQS4

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EDK II UEFI APPLICATION

Defining a UEFI Application

Characteristics of a UEFI Loadable Image

- Loaded by UEFI loader, just like drivers
- Does not register protocols
- Consumes protocols
- Typically exits when completed (user driven)
- Same set of interfaces as drivers available

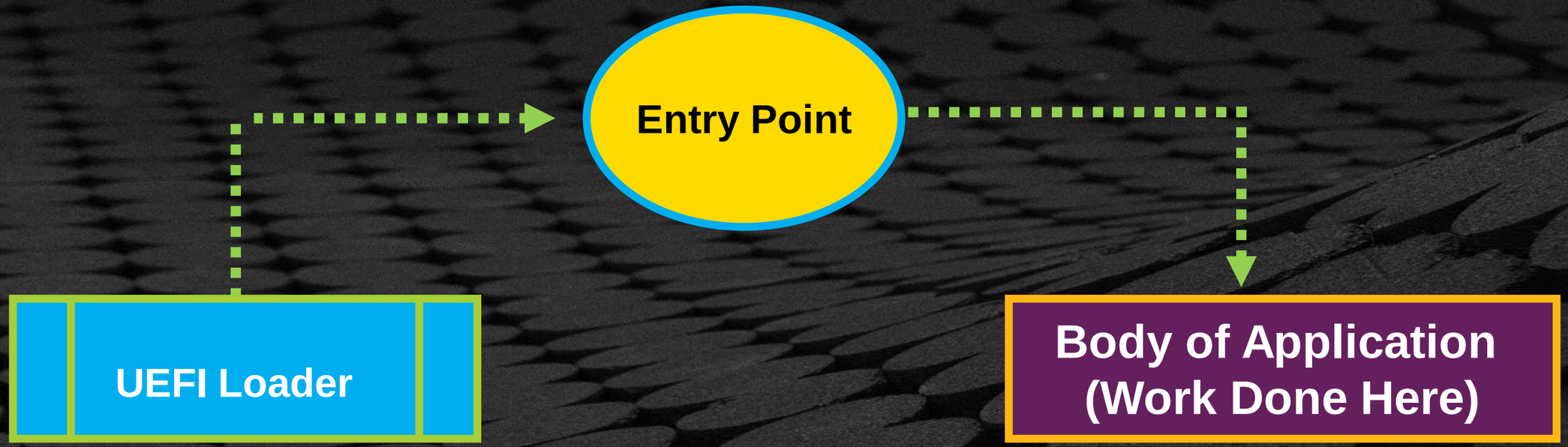
Defining a UEFI Application

UEFI Loadable Image Usages

- Platform Diagnostics
- Factory Diagnostics
- Utilities
- Driver Prototyping
- “Platform” Applications
- Portable Across Platforms (IA32, X64, ARM, Itanium, etc.)

Executing Applications

Executing Applications



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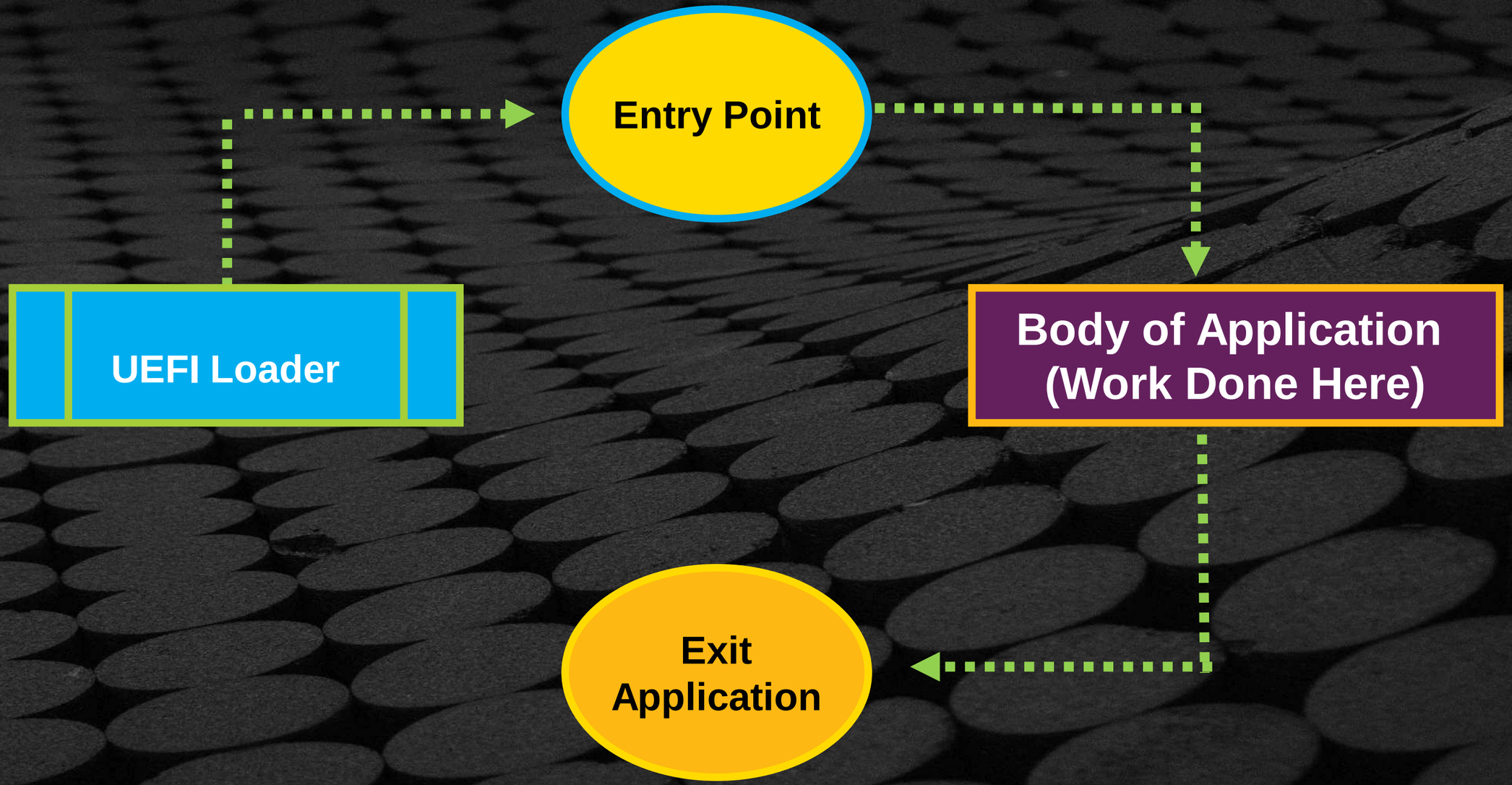

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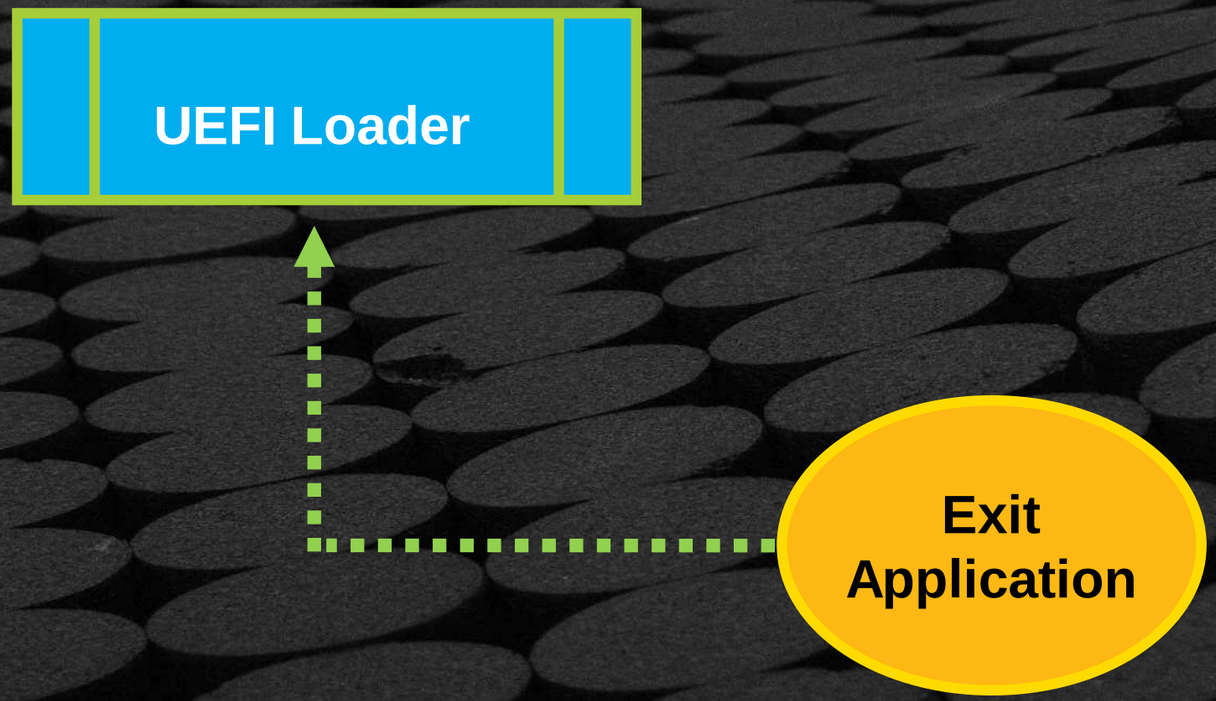
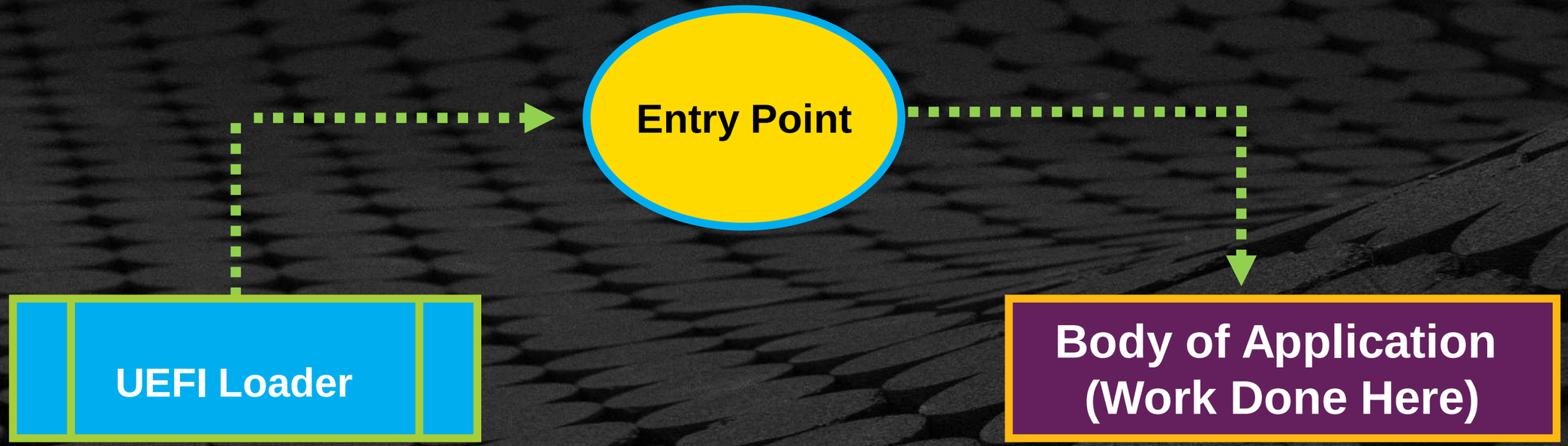


Executing Applications

Executing Applications

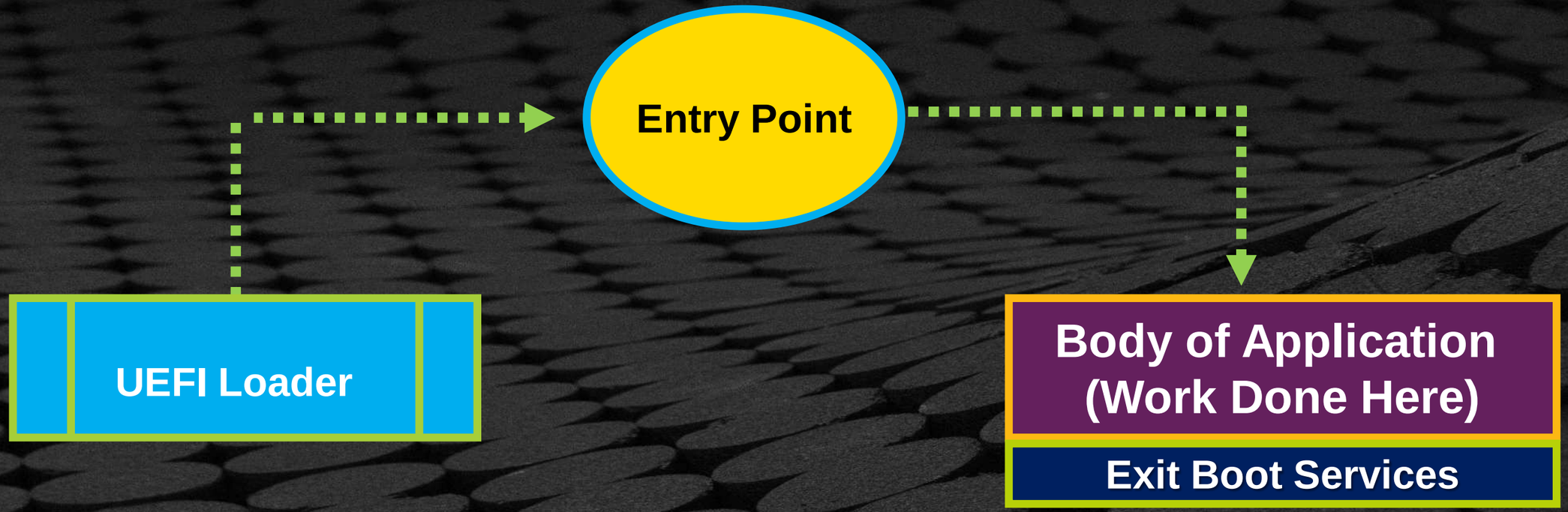
OS Loader

Executing Applications



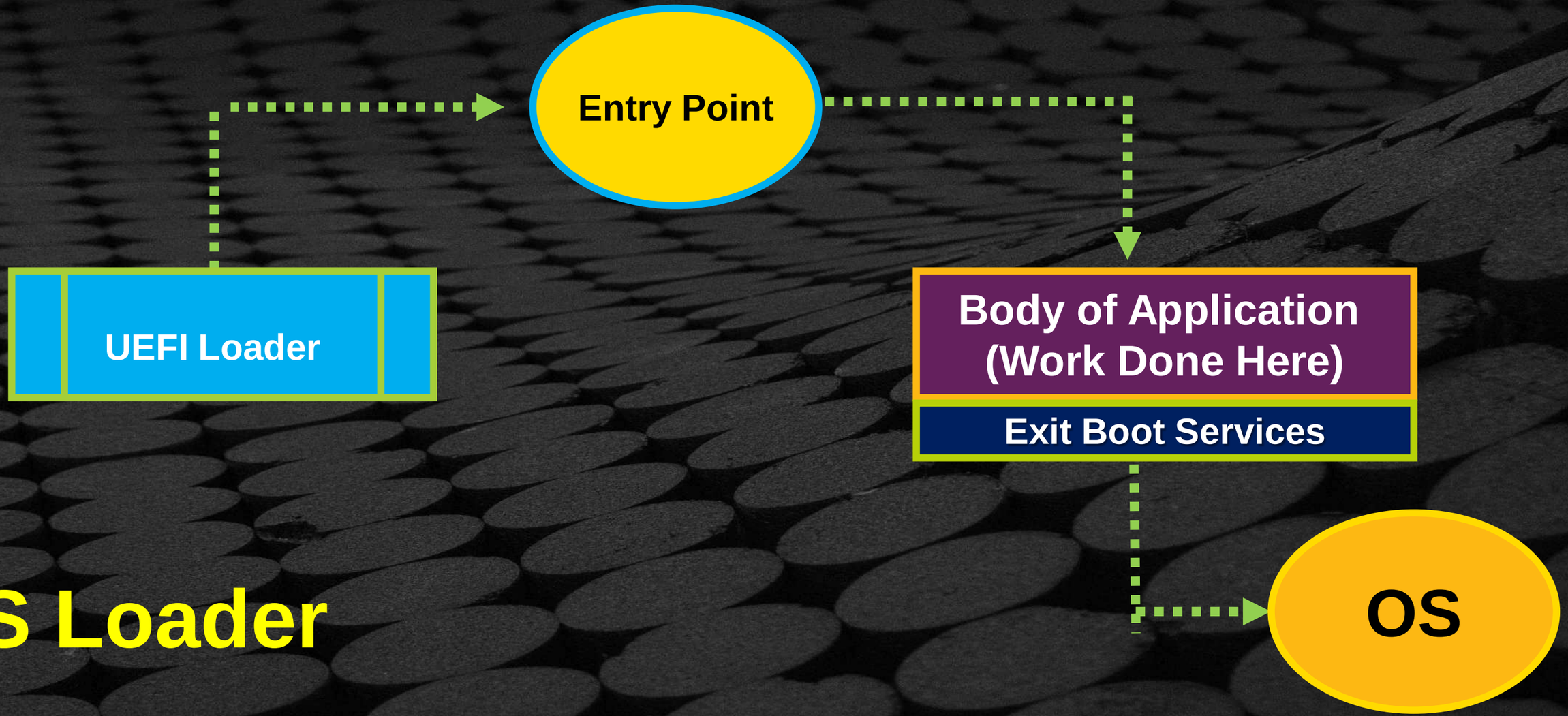
OS Loader

Executing Applications



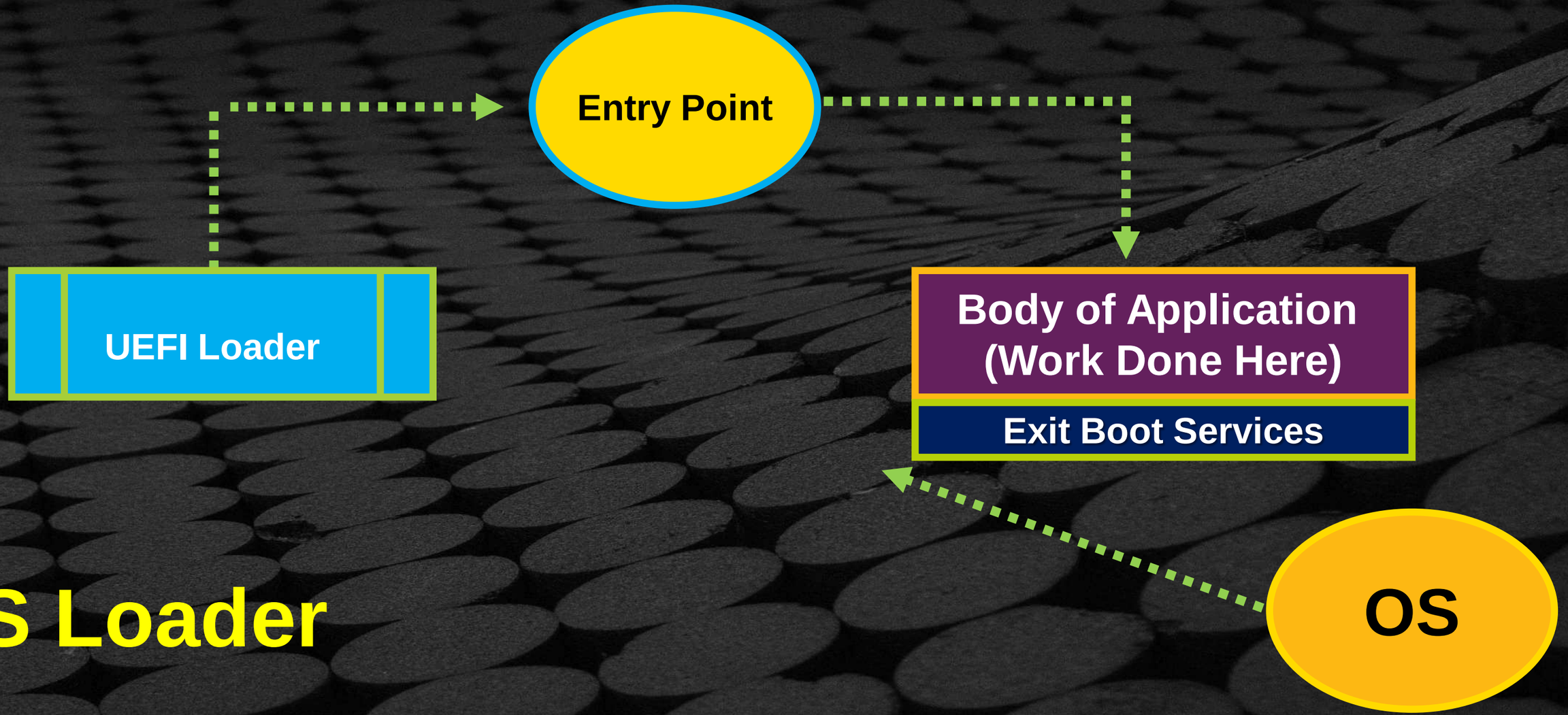
OS Loader

Executing Applications



OS Loader

Executing Applications



OS Loader

Executing Applications

OS Loader

Driver Vs. Application

	Driver	Application
Loaded by:	UEFI Loader	UEFI Loader
Interfaces available:	ALL	ALL
Consume protocols?	YES	YES
Produce protocols?	YES	NO
Typically driven by?	System	User
Typical use	Support HW	Any

Driver Vs. Application

	Driver	Application
Loaded by:	UEFI Loader	UEFI Loader
Interfaces available:	ALL	ALL
Consume protocols?	YES	YES
Produce protocols?	YES	NO
Typically driven by?	System	User
Typical use	Support HW	Any

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	Driver	Application
Loaded by:	UEFI Loader	UEFI Loader
Interfaces available:	ALL	ALL
Consume protocols?	YES	YES
Produce protocols?	YES	NO
Typically driven by?	System	User
Typical use	Support HW	Any

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EDK II UEFI APPLICATIONS

How to Write a EDK II UEFI Application

Application Files Placement

- Application source code can go anywhere in the EDK II workspace

Application Files Placement

- Application source code can go anywhere in the EDK II workspace
- All code and include files go under a single directory containing an INF

Application Files Placement

- Application source code can go anywhere in the EDK II workspace
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- EDK Sample Applications can be found here:

```
/MdeModulePkg/Application
```

Application Files Placement

- Application source code can go anywhere in the EDK II workspace
- All code and include files go under a single directory containing an INF
- EDK Sample Applications can be found here:

```
/MdeModulePkg/Application
```

- Typically, modules reside within a package:

```
/MyWorkSpace
   /MyPkg
      /Application
         /MyApp
```

```
MyApp.c
MyApp.inf
```

Module .INF File

Syntax

INF text file example

```
INFfile ::=[<Header>]
            <Defines>
            [<BuildOptions>]
            [<Sources>]
            [<Binaries>]
            [<Guids>]
            [<Protocols>]
            [<Ppis>]
            [<Packages>]
            [<LibraryClasses>]
            [<Pcds>]
            [<UserExtensions>]
            [<Depex>]
```

Application INF Files [DEFINES]

Field	Description
INF_VERSION	1.25* - Version of the INF spec.
BASE_NAME	What's the name of the application
FILE_GUID	Create a GUID for your module
MODULE_UNI_FILE	Meta-data - localization for Description & Abstract
VERSION_STRING	Version number
ENTRY_POINT	Name of the function to call
MODULE_TYPE	UEFI_APPLICATION

* EDK II Specifications: https://github.com/tianocore/tianocore.github.io/wiki/EDK-II-Specifications

Sample INF file

```
[Defines]
  INF_VERSION                    = 0x00010005
  BASE_NAME                      = MyApplication
  FILE_GUID                      = 10C75C00-30 . . .
  MODULE_TYPE                    = UEFI_APPLICATION
  VERSION_STRING                 = 1.0
  ENTRY_POINT                    = UefiMain
[Sources]
  MyFile.c

[Packages]
  MdePkg/MdePkg.dec

[LibraryClasses]
  UefiApplicationEntryPoint

[Guids]

[Ppis]

[Protocols]
```

Sample INF file

```
[Defines]
  INF_VERSION                    = 0x00010005
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  MODULE_TYPE                    = UEFI_APPLICATION
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  ENTRY_POINT                    = UefiMain
[Sources]
  MyFile.c

[Packages]
  MdePkg/MdePkg.dec

[LibraryClasses]
  UefiApplicationEntryPoint

[Guids]

[Ppis]

[Protocols]
```

BUILDING AN APPLICATION

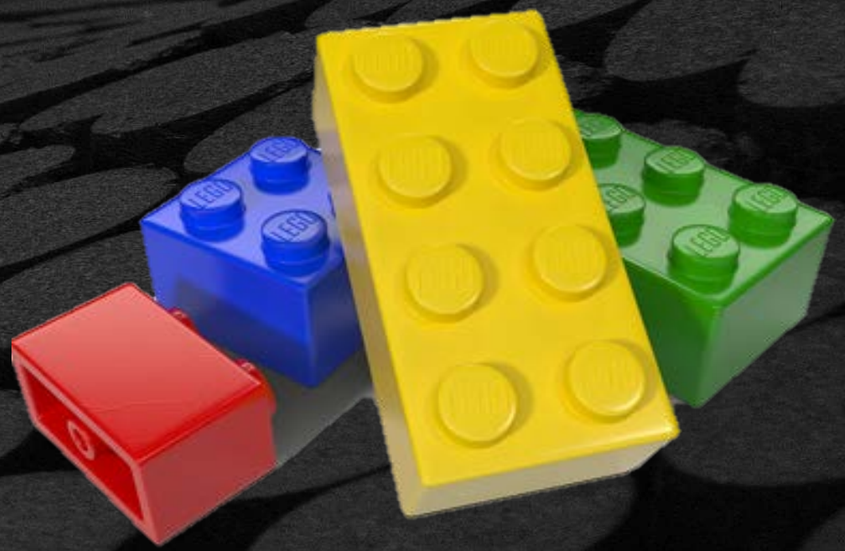
Platform .DSC references .INF

Runs:

"Build" for the entire platform

OR

"Build" in the application's directory



Sample Application ‘C’ file

```
#include <Uefi.h>
#include <Library/UefiApplicationEntryPoint.h>


EFI_STATUS
EFIAPI
UefiMain (
  IN EFI_HANDLE        ImageHandle,
  IN EFI_SYSTEM_TABLE  *SystemTable
  )
{
  return EFI_SUCCESS;
}
```

Sample Application ‘C’ file

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#include <Uefi.h>
#include <Library/UefiApplicationEntryPoint.h>


EFI_STATUS
EFIAPI
UefiMain (
  IN EFI_HANDLE        ImageHandle,
  IN EFI_SYSTEM_TABLE  *SystemTable
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{
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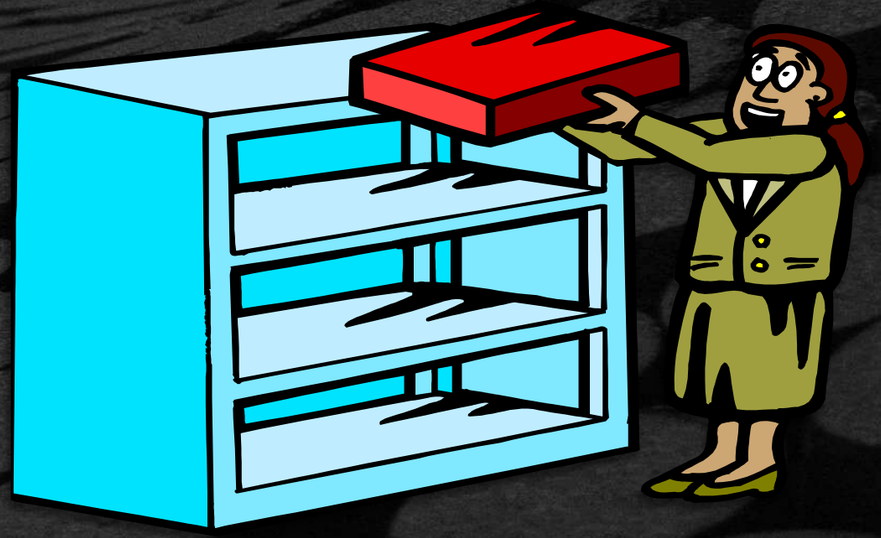
}
```

UEFI Application Vs. EADK Application

EDK II Application Development Kit includes the Standard C Libraries in UEFI Shell Applications

Off the shelf “C” application Converted to UEFI application



Sample INF file using EDK II EADK

```
[Defines]
  INF_VERSION                    = 0x00010005
  BASE_NAME                      = MyApplication
  FILE_GUID                      = 10C75C00-30 . . .
  MODULE_TYPE                    = UEFI_APPLICATION
  VERSION_STRING                 = 1.0
  ENTRY_POINT                    = ShellCEntryLib
[Sources]
  MyFile.c

[Packages]
  StdLib/StdLib.dec
  ShellPkg/ShellPkg.dec
  MdePkg/MdePkg.dec

[LibraryClasses]
  LibC
  LibStdio
```

Sample INF file using EDK II EADK

```
[Defines]
  INF_VERSION                    = 0x00010005
  BASE_NAME                      = MyApplication
  FILE_GUID                      = 10C75C00-30 . . .
  MODULE_TYPE                    = UEFI_APPLICATION
  VERSION_STRING                 = 1.0
  ENTRY_POINT                    = ShellCEntryLib
[Sources]
  MyFile.c

[Packages]
  StdLib/StdLib.dec
  ShellPkg/ShellPkg.dec
  MdePkg/MdePkg.dec

[LibraryClasses]
  LibC
  LibStdio
```

Sample Application ‘C’ file Using EDK II EADK

This sample looks a lot like actual “C” source.

```
#include <stdio.h>

int
Main (
  IN int Argc,
  IN char **Argv
  )
{
  return 0;
}
```

Driver File Placement

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```
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IntelFrameworkModulePkg/Universal/BdsDxe
```

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```
MdeModulePkg/Bus/Scsi/ScsiDiskDxe
IntelFrameworkModulePkg/Universal/BdsDxe
```

- Drivers normally reside in a package

Driver INF Files: [DEFINES]

Field	Description
INF_VERSION	1.25* - Version of the INF spec.
BASE_NAME	What's the name of the driver
FILE_GUID	Create a GUID for your module
MODULE_UNI_FILE	Meta-data - localization for Description & Abstract
VERSION_STRING	Version number
ENTRY_POINT	Name of the function to call
MODULE_TYPE	UEFI_DRIVER, DXE_DRIVER, PEIM, or others

Changes for a UEFI Driver Module

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UEFI Driver Module requirements:

- Driver Binding Protocol
- Component Name2 Protocol (recommended)

DXE/PEIM/other Driver requirements

Sample INF file

```
[Defines]
  INF_VERSION                    = 0x00010005
  BASE_NAME                      = MyApplication
  FILE_GUID                      = 10C75C00-30 . . .
  MODULE_TYPE                    = UEFI_DRIVER
  VERSION_STRING                 = 1.0
  ENTRY_POINT                    = UefiMain
[Sources]
  MyFile.c

[Packages]
  MdePkg/MdePkg.dec

[LibraryClasses]
  UefiDriverEntryPoint

[Guids]

[Ppis]

[Protocols]
```

INF Usage Fields – DIST files

UEFI Spec – Package Distribution

Optional

Usage Fields used by Build tools for creating the .Dist files for BIN Modules

- **[GUID]**
- **[PCD]**
- **[PROTOCOL]**
- **[PPIS]**

1 Usage Block – “##” After the entry

n Usage Blocks – “##” Precede the entry

Usage Key Word

```
## UNDEFINED
## CONSUMES
## SOMETIMES_CONSUMES
## PRODUCES
## SOMETIMES_PRODUCES
## TO_START
## BY_START
## NOTIFY
```

UEFI Protocol

INF File Usage Block examples

```
[Guids]
  ## SOMETIMES_PRODUCES ## Variable:L"ConInDev"
  ## SOMETIMES_CONSUMES ## Variable:L"ConInDev"
  ## SOMETIMES_PRODUCES ## Variable:L"ConOutDev"
  ## SOMETIMES_CONSUMES ## Variable:L"ConOutDev“
  ## SOMETIMES_PRODUCES ## Variable:L"ErrOutDev"
  ## SOMETIMES_CONSUMES ## Variable:L"ErrOutDev"
  gEfiGlobalVariableGuid
  gEfiVTUTF8Guid                          ## SOMETIMES_CONSUMES ## GUID # used with a Vendor-Defined
  gEfiVT100Guid                           ## SOMETIMES_CONSUMES ## GUID # used with a Vendor-Defined
  gEfiVT100PlusGuid                       ## SOMETIMES_CONSUMES ## GUID # used with a Vendor-Defined
  gEfiPcAnsiGuid                          ## SOMETIMES_CONSUMES ## GUID # used with a Vendor-Defined
  gEfiTtyTermGuid                         ## SOMETIMES_CONSUMES ## GUID # used with a Vendor-Defined
  gEdkiiStatusCodeDataTypeVariableGuid ## SOMETIMES_CONSUMES ## GUID
```

Example: TerminalDxe.inf

INF File Usage Block examples

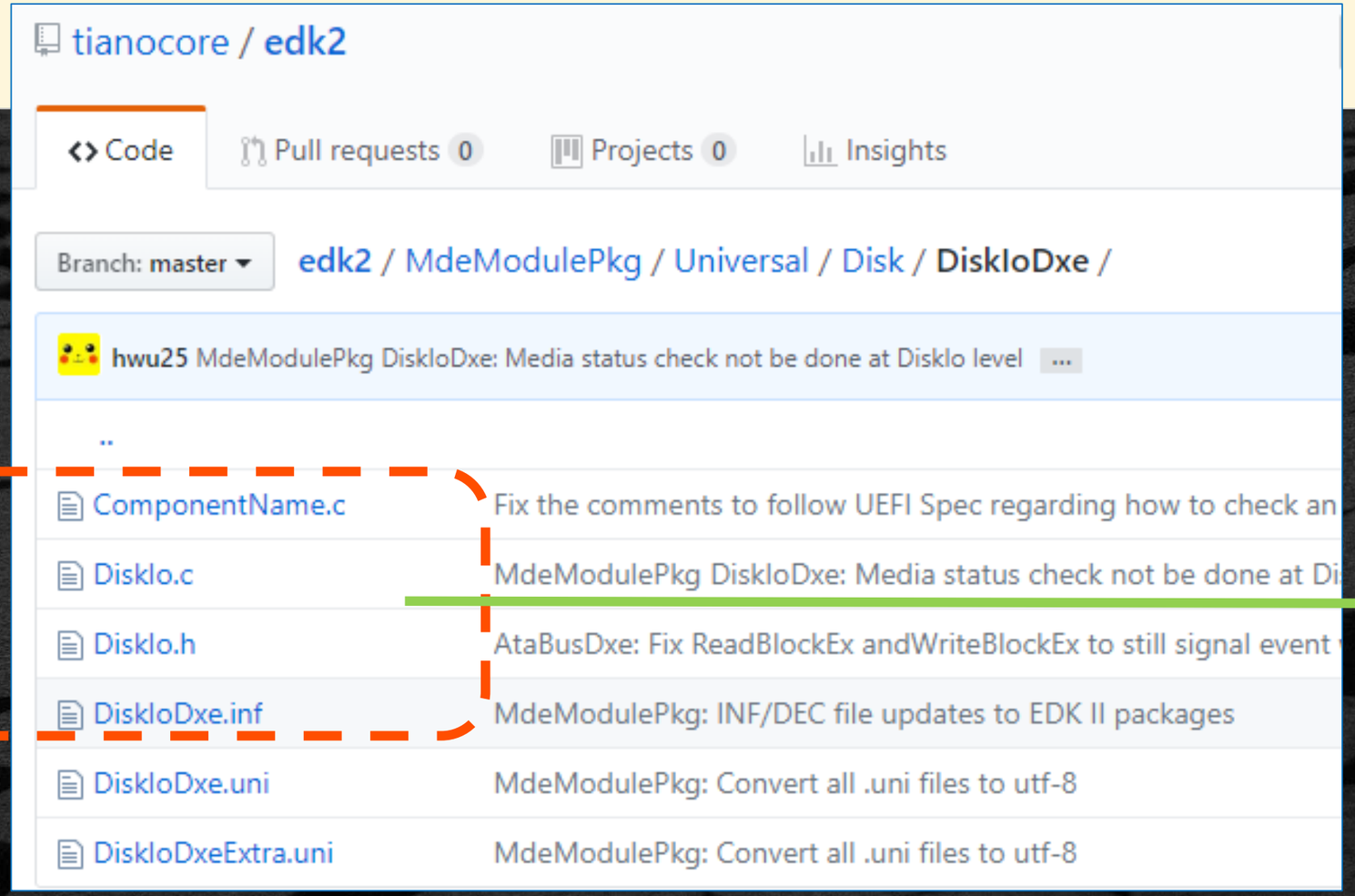
```
[Protocols]
  gEfiSerialIoProtocolGuid              ## TO_START
  ## BY_START
  ## TO_START
  gEfiDevicePathProtocolGuid
  gEfiSimpleTextInProtocolGuid          ## BY_START
  gEfiSimpleTextInputExProtocolGuid     ## BY_START
  gEfiSimpleTextOutProtocolGuid         ## BY_START

[Pcd]
  gEfiMdePkgTokenSpaceGuid.PcdDefaultTerminalType           ## SOMETIMES_CONSUMES
  gEfiMdeModulePkgTokenSpaceGuid.PcdErrorCodeSetVariable    ## CONSUMES
```

Example: TerminalDxe.inf

UEFI Driver Example – Disk I/O

https://github.com/tianocore/edk2/MdeModulePkg/Universal/Disk/DiskIoDxe



Driver Binding
- Supported
- Start
- Stop

UEFI Driver Example – Disk I/O

https://github.com/tianocore/edk2/.../Disk/DiskIoDxe

Entry Point

"C" File

```
EFI_STATUS
EFIAPI
InitializeDiskIo (
  IN EFI_HANDLE           ImageHandle,
  IN EFI_SYSTEM_TABLE     *SystemTable
  )
{
  // . . .
  Status = EfiLibInstallDriverBindingComponentName2 (
             ImageHandle,
             SystemTable,
             &gDiskIoDriverBinding,
             ImageHandle,
             &gDiskIoComponentName,
             &gDiskIoComponentName2
             );
  ASSERT_EFI_ERROR (Status);
  return Status;
}
```

INF File

```
[Defines]
  . . .
ENTRY_POINT     = InitializeDiskIo
```

UEFI Driver Example – Disk I/O

https://github.com/tianocore/edk2/.../Disk/DiskIoDxe

Supported

"C" File

```
EFI_STATUS
EFIAPI
DiskIoDriverBindingSupported (
  IN EFI_DRIVER_BINDING_PROTOCOL  *This,
  IN EFI_HANDLE                   ControllerHandle,
  IN EFI_DEVICE_PATH_PROTOCOL     *RemainingDevicePath
OPTIONAL
  )
{
  Status = gBS->OpenProtocol (
    ControllerHandle,
      &gEfiBlockIoProtocolGuid,
      (VOID **) &BlockIo,
      This->DriverBindingHandle,
      ControllerHandle,
      EFI_OPEN_PROTOCOL_BY_DRIVER
    );
```

INF File

```
[Protocols]
  ...
  gEfiBlockIoProtocolGuid   ## TO_START
```

UEFI Driver Example – Disk I/O

https://github.com/tianocore/edk2/.../Disk/DiskIoDxe

Start

"C" File

```
EFI_STATUS
EFIAPI
 DiskIoDriverBindingStart (
  IN EFI_DRIVER_BINDING_PROTOCOL  *This,
  IN EFI_HANDLE                   ControllerHandle,
  IN EFI_DEVICE_PATH_PROTOCOL     *RemainingDevicePath
OPTIONAL
  )
{

  if (Instance->BlockIo2 != NULL) {
    Status = gBS->InstallMultipleProtocolInterfaces (
    &ControllerHandle,
    &gEfiDiskIoProtocolGuid,  &Instance->DiskIo,
    &gEfiDiskIo2ProtocolGuid, &Instance->DiskIo2,
    NULL
    );
```

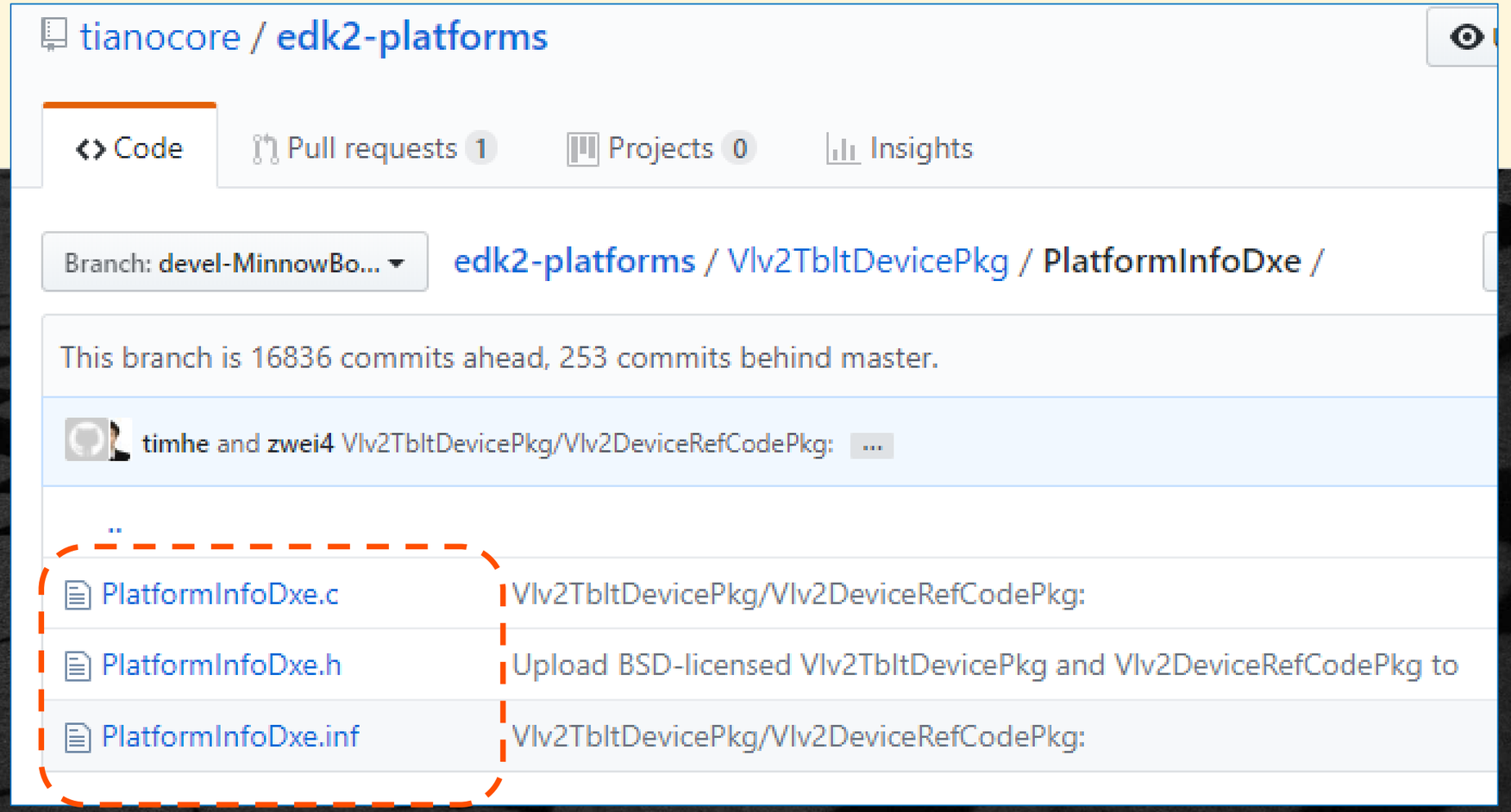
INF File

```
[Protocols]

gEfiDiskIoProtocolGuid  ## BY_START
gEfiDiskIo2ProtocolGuid ## BY_START
```

DXE Driver Example - PlatformInfoDxe

https://github.com/tianocore/edk2-platforms/MinnowBoardMax../PlatformInforDxe/



DXE Driver Example – PlatformInfoDxe

https://github.com/tianocore/edk2-platforms/ PlatformInfoDxe

Entry Point

"C" File

```
#include "PlatformInfoDxe.h"
• • •
EFI_STATUS
EFIAPI
PlatformInfoInit (
  IN EFI_HANDLE         ImageHandle,
  IN EFI_SYSTEM_TABLE   *SystemTable
  )
/*++
{
// • • •
  return Status;
}
```

INF File

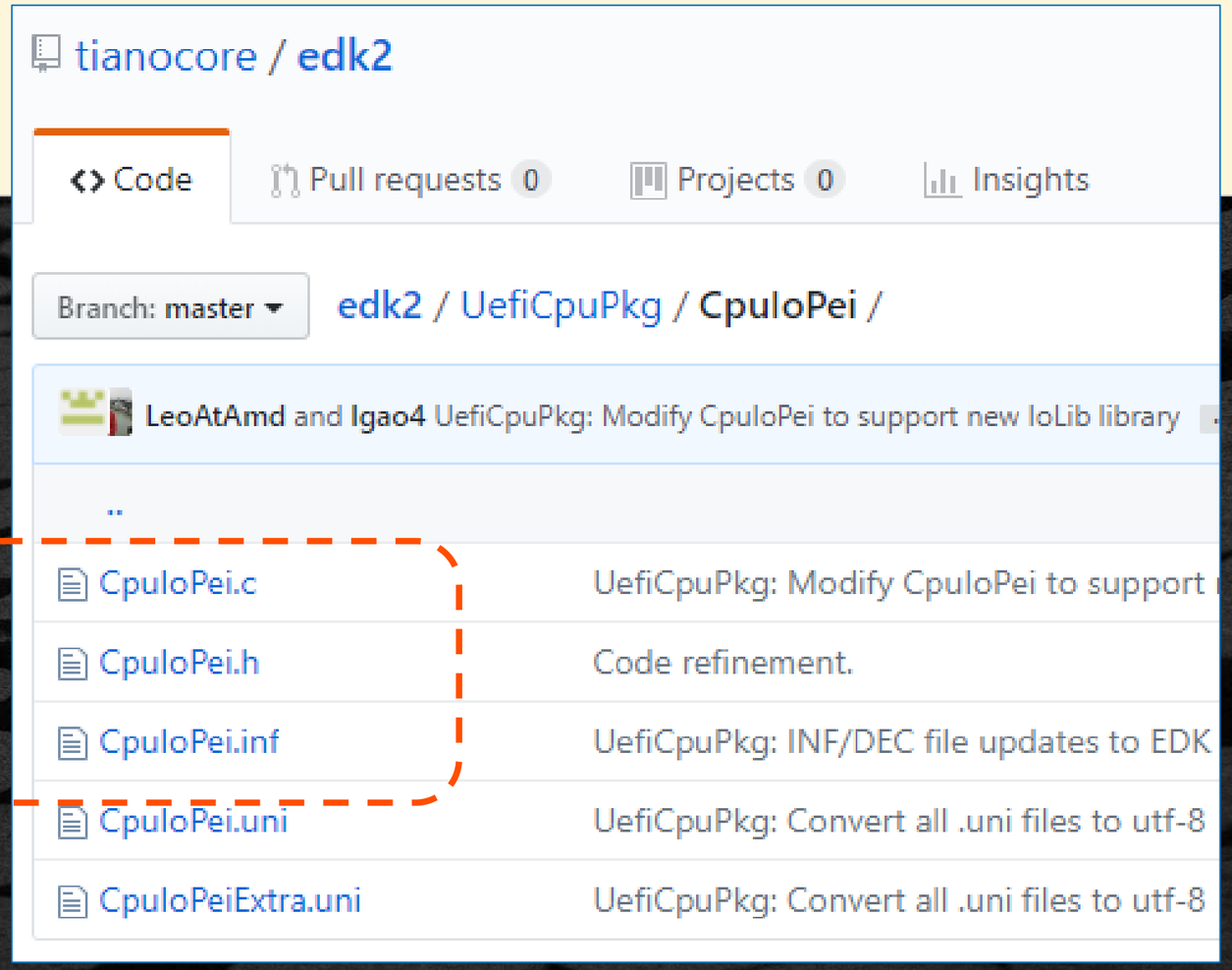
```
[Defines]
 • • •
  MODULE_TYPE      = DXE_DRIVER
  VERSION_STRING   = 1.0
  ENTRY_POINT      = PlatformInfoInit
 • • •

[Depex]
  gEfiVariableArchProtocolGuid AND
   gEfiVariableWriteArchProtocolGuid
```

Notice the MODULE TYPE, C function Entry point and the [Depex] differences in the INF file

PEI Driver (PEIM) Example - CpuIoPei

https://github.com/tianocore/edk2/UefiCpuPkg/CpuIoPei



PEI Driver (PEIM) Example – CpuIoPei

https://github.com/tianocore/edk2/UefiCpuPkg/CpuIoPei

Entry Point

"C" File

```
#include "CpuIoPei.h"
 //. . .
EFI_STATUS
EFIAPI
CpuIoInitialize (
  IN EFI_PEI_FILE_HANDLE     FileHandle,
  IN CONST EFI_PEI_SERVICES  **PeiServices
  )
{
  EFI_STATUS  Status;
 //. . .
  return EFI_SUCCESS;
}
```

INF File

```
[Defines]
 . . .
  MODULE_TYPE        = PEIM
  VERSION_STRING     = 1.0
  ENTRY_POINT        = CpuIoInitialize
 . . .

[Depex]
   TRUE
```

LESSON OBJECTIVE

- What is a EDK II Module
- Use EDK II libraries to write UEFI apps/drivers
- How to Define a UEFI application
- Differences between UEFI App / Drivers INF file

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