

PCIe Hot Plug on Windows

Though the OS supports PCIe hot plug, on-premise indicators are incomplete. A method to establish system support for hot plug is put forward.

- In Device Manager, hot plug support is part of Root Complex properties, PCIExpressNativeHotPlugControl. If it is absent, then the platform does not grant *native hot plug*.

```
PS > (
    Get-PnpDevice -InstanceId "ACPI\PNP0A08*" | Get-PnpDeviceProperty
    DEVPKEY_PciRootBus_PCIExpressNativeHotPlugControl |
    Where-Object { $_.Data }
).InstanceId
```

At startup, the OS feeds the *supported and controlled PCIe* features to the **ACPI _OSC method**. System firmware responds with a bitmask for granted features, part of *Control* field. *Section 4.5 / PCI Firmware Specification Revision 3.2*.

- In kernel mode, the root complex fully qualified name must be identified. Use `!amli find _OSC` and look at the 1st entry, as a child of `_SB.XXXX`. The `_HID` must match *EISAID("PNP0A08")*.

```
0: kd> !amli find _OSC
\_SB.PCI0._OSC
\_SB.PR00._OSC
\_SB.PR01._OSC
\_SB.PR02._OSC
\_SB.PR03._OSC
...
\_SB._OSC
0: kd> !amli dns /v \_SB.PCI0._HID
Integer(_HID:Value=0x00000000080ad041[134926401])
0: kd> !amli dns /v \_SB.PCI0.SUPP
ACPI Name Space: \_SB.PCI0.SUPP (ffffbb0e1bf6e330)
Integer(SUPP:Value=0x000000000000001f[31])
0: kd> !amli dns /v \_SB.PCI0.CTRL
ACPI Name Space: \_SB.PCI0.CTRL (ffffbb0e1bf6e3e0)
Integer(CTRL:Value=0x0000000000000015[21])
```

`_OSC` method suffers minor changes between processor generations. Within a generation, there are *use conditions* that demand different implementation.

Intel maintains a compact firmware implementation through [slimbootloader](#) project. The `_OSC` method is implemented in **HostBus.asl** for each CPU platform.

CTRL ACPI variable shows the granted access from firmware to OS. Bit 0 represents

PCI Express Native Hot Plug control

The operating system sets this bit to 1 to request control over PCI Express native hot plug. If the operating system successfully receives control of this feature, it must track and update the status of hot plug slots and handle hot plug events as described in the PCI Express Base Specification (including determining whether the associated slot(s) support hot plug).

The OS registers interrupt handlers for root port or downstream port.

```
0: kd> !idt
Dumping IDT: fffff8070701e000
50: pci!ExpressRootPortMessageRoutine (KINTERRUPT fffffa7016b711a00)
51: pci!ExpressDownstreamSwitchPortInterruptRoutine (KINTERRUPT fffffa7016b711000)
...
60: pci!ExpressRootPortMessageRoutine (KINTERRUPT fffffa7016b711b40)
61: pci!ExpressDownstreamSwitchPortInterruptRoutine (KINTERRUPT fffffa7016bfd6dc0)
```

The absence of these interrupts indicates lack of hot plug support.

Algorithm

Hot plug is handled by the ISR, DPC and collateral timer for error handling. Overview:

```

if (!SlotControl.HotPlugInterruptEnable) {
    return;
}
if (SlotControl.PresenceDetectEnable && SlotStatus.PresenceDetectChanged) {
    WtC(SlotStatus.PresentDetectChanged);
    if (SlotStatus.PresenceDetectState) {
        call nt!IoInvalidateDeviceRelations;
    } else {
        call nt!IoRequestDeviceEjectEx;
    }
}
}

```

With `IoInvalidateDeviceRelations`, the PnP manager issues `IRP_MN_QUERY_DEVICE_RELATIONS` on the port. The PCI driver rescans the bus, creates a new device object.

```

pci!PciBus_QueryDeviceRelations
pci!PciScanBus
pci!PciProcessNewDevice
    lock xadd dword ptr [pci!PciDeviceSequenceNumber (fffff807`194fc250)],r9d
    lea r8,[pci!`string' (fffff807`194f3af0)] = "\Device\NTPNP_PCI%04d"
    nt!IoCreateDevice

```

Tracing

Several opcodes indicate *ETW* support.

```

pci!PciDevice_Start+0x13a93:
fffff807`1951e423 833d9edcfdff05 cmp     dword ptr [pci!EntryReg+0x18 (fffff807`194fc0c8)],5
fffff807`1951e42a 0f86c8000000 jbe     pci!PciDevice_Start+0x13b68 (fffff807`1951e4f8)
pci!PciDevice_Start+0x13aa0:
fffff807`1951e430 e8e754fcff      call    pci!TlgKeywordOn (fffff807`194e391c)
...
pci!PciPreScanAssignBusNumbersSubtree+0x58:
fffff807`1952e558 833d69dbfcff05 cmp     dword ptr [pci!EntryReg+0x18 (fffff807`194fc0c8)],5
...
pci!PciProcessNewRootBus+0x178:
fffff807`19514d74 833d4d73feff05 cmp     dword ptr [pci!EntryReg+0x18 (fffff807`194fc0c8)],5
...
fffff807`194ec46b 833d56fc000005 cmp     dword ptr [pci!EntryReg+0x18 (fffff807`194fc0c8)],5
fffff807`194ec472 0f86f7000000 jbe     pci!PciStartHotPlugController+0x17b (fffff807`194ec56f)
pci!PciStartHotPlugController+0x84:
fffff807`194ec478 e89f74ffff      call    pci!TlgKeywordOn (fffff807`194e391c)

```

The `logman.exe start -p <GUID>` that can be used is undocumented.

```

0: kd> uf pci!TraceLoggingRegisterEx
fffff807`1951c3b1 488b0518fdfdff mov     rax,qword ptr [pci!EntryReg+0x20 (fffff807`194fc0d0)]
fffff807`1951c3d0 488d4c2420      lea     rcx,[rsp+20h]
fffff807`1951c3d5 0f1040f0       movups  xmm0,xmmword ptr [rax-10h]
fffff807`1951c3e1 f30f7f442420   movdqu  xmmword ptr [rsp+20h],xmm0
fffff807`1951c3ee e80d37baea     call    nt!EtwRegister (fffff807`040bfb00)

```

```

0: kd> dt nt!_GUID poi(pci!EntryReg+0x20)-0x10
{69a770dd-1cdb-46c0-91c9-cd2a9b76e061}

```

Automation

[NativeHotPlugSupport.ps1](#) shows:

1. ACPI `_OSC` implementation, `SUPP` and `CTRL` values
2. hot plug ISRs in the interrupt descriptor table
3. device objects that connect the interrupt
4. CPU name and model

```

PS > .\NativeHotPlugSupport.ps1 -Path .\MEMORY.DMP
ffffbb0e1bf6e6b2:[\_SB.PCI0._OSC]
ffffbb0e1bf6e6b2 : Store(Arg3, Local0)
ffffbb0e1bf6e6b5 : CreateWordField(Local0, Zero, CDW1)
ffffbb0e1bf6e6bc : CreateWordField(Local0, 0x4, CDW2)
ffffbb0e1bf6e6c4 : CreateWordField(Local0, 0x8, CDW3)
ffffbb0e1bf6e6cc : If(LEqual(Arg0, GUID))
ffffbb0e1bf6e6d5 : {
ffffbb0e1bf6e6d5 : | Store(CDW2, SUPP)
ffffbb0e1bf6e6de : | Store(CDW3, CTRL)
ffffbb0e1bf6e6e7 : | If(LNot(NEXP))
ffffbb0e1bf6e6ee : | {
ffffbb0e1bf6e6ee : | | And(CTRL, 0xffffffff8, CTRL)
ffffbb0e1bf6e6fc : | }
ffffbb0e1bf6e6fc : | If(LEqual(TBTS, One))
ffffbb0e1bf6e704 : | {
ffffbb0e1bf6e704 : | | And(CTRL, 0xffffffff7, CTRL)
ffffbb0e1bf6e712 : | }
ffffbb0e1bf6e712 : | If(Not(And(CDW1, One, ), ))
ffffbb0e1bf6e71d : | {
ffffbb0e1bf6e71d : | | If(And(CTRL, One, ))
ffffbb0e1bf6e726 : | | {
ffffbb0e1bf6e726 : | | | NHPG()
ffffbb0e1bf6e72a : | | }
ffffbb0e1bf6e72a : | | If(And(CTRL, 0x4, ))
ffffbb0e1bf6e734 : | | {
ffffbb0e1bf6e734 : | | | NPME()
ffffbb0e1bf6e738 : | | }
ffffbb0e1bf6e738 : | }
ffffbb0e1bf6e738 : | If(LNot(LEqual(Arg1, One)))
ffffbb0e1bf6e73e : | {
ffffbb0e1bf6e73e : | | Or(CDW1, 0x8, CDW1)
ffffbb0e1bf6e749 : | }
ffffbb0e1bf6e749 : | If(LNot(LEqual(CDW3, CTRL)))
ffffbb0e1bf6e755 : | {
ffffbb0e1bf6e755 : | | Or(CDW1, 0x10, CDW1)
ffffbb0e1bf6e760 : | }
ffffbb0e1bf6e760 : | Store(CTRL, CDW3)
ffffbb0e1bf6e769 : | Store(CTRL, OSCC)
ffffbb0e1bf6e772 : | Return(Local0)
ffffbb0e1bf6e774 : }
ffffbb0e1bf6e774 : Else
ffffbb0e1bf6e776 : {
ffffbb0e1bf6e776 : | Or(CDW1, 0x4, CDW1)
ffffbb0e1bf6e781 : | Return(Local0)
ffffbb0e1bf6e783 : }

ffffbb0e1e9b825a:[\NHPG]
ffffbb0e1e9b825a : Store(Zero, \_SB_.PCI0.RP01.HPEX)
ffffbb0e1e9b826f : Store(Zero, \_SB_.PCI0.RP02.HPEX)
ffffbb0e1e9b8452 : Store(One, \_SB_.PCI0.RP01.HPSX)
ffffbb0e1e9b8467 : Store(One, \_SB_.PCI0.RP02.HPSX)

Integer(SUPP:Value=0x000000000000001f[31])
Integer(CTRL:Value=0x0000000000000015[21])

50: pci!ExpressRootPortMessageRoutine (KINTERRUPT ffffa7016b711a00)
PDO Extension, Bus 0x0, Device 1b, Function 6.
  DevObj 0xffffbb0e1c7f8060 Parent FDO DevExt 0xffffbb0e1aa04a30
  Vendor ID 8086 (INTEL CORPORATION) Device ID A32E
  Subsystem Vendor ID 8086 (INTEL CORPORATION) Subsystem ID 7270

```

```

51: pci!ExpressDownstreamSwitchPortInterruptRoutine (KINTERRUPT ffffa7016b711000)
PDO Extension, Bus 0x2e, Device 0, Function 0.
  DevObj 0xffffbb0e1c9b4570 Parent FDO DevExt 0xffffbb0e1c9064c0
  Vendor ID 10b5 (PLX TECHNOLOGY, INC.) Device ID 8724
  Subsystem Vendor ID 10b5 (PLX TECHNOLOGY, INC.) Subsystem ID 8724

60: pci!ExpressRootPortMessageRoutine (KINTERRUPT ffffa7016b711b40)
PDO Extension, Bus 0x0, Device 1b, Function 0.
  DevObj 0xffffbb0e1c7f7060 Parent FDO DevExt 0xffffbb0e1aa04a30
  Vendor ID 8086 (INTEL CORPORATION) Device ID A32C
  Subsystem Vendor ID 8086 (INTEL CORPORATION) Subsystem ID 7270

61: pci!ExpressDownstreamSwitchPortInterruptRoutine (KINTERRUPT ffffa7016bfd6dc0)
PDO Extension, Bus 0x2e, Device 1, Function 0.
  DevObj 0xffffbb0e1c9b5730 Parent FDO DevExt 0xffffbb0e1c9064c0
  Vendor ID 10b5 (PLX TECHNOLOGY, INC.) Device ID 8724
  Subsystem Vendor ID 10b5 (PLX TECHNOLOGY, INC.) Subsystem ID 8724

ProcessorNameString = REG_SZ Intel(R) Core(TM) i7-9850HE CPU @ 2.70GHz
Identifier = REG_SZ Intel64 Family 6 Model 158 Stepping 10

```

Notes

- IT personnel can use **DEVPKEY_PciRootBus_PCIExpressNativeHotPlugControl** to reveal hot plug support.
- Escalation accounts for **ACPI _OSC** method and **CTRL** value for the host bridge, part of the root complex.
- ETW traces can be enabled with **{69a770dd-1cdb-46c0-91c9-cd2a9b76e061}** provider.
- To locate the root or downstream ports that own the hot plug interrupt, dump the IDT, match the **KINTERRUPT→ConnectionData→Vectors[0].ControllerInput.Gsiv** with **!arbiter 4**

```

PS > $prefix = "https://raw.githubusercontent.com/armaber/scripts/refs/heads/main/";
    "Detect_OSC.js", "NativeHotPlugSupport.ps1" | foreach {
        Invoke-WebRequest $prefix/$NativeHotPlugSupport/$PSItem -OutFile $PSItem;
    }

```