Multi-ISA Firmware Compatibility

Bringing RISC-V and IHV Ecosystems Together

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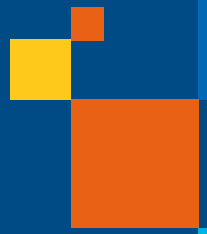

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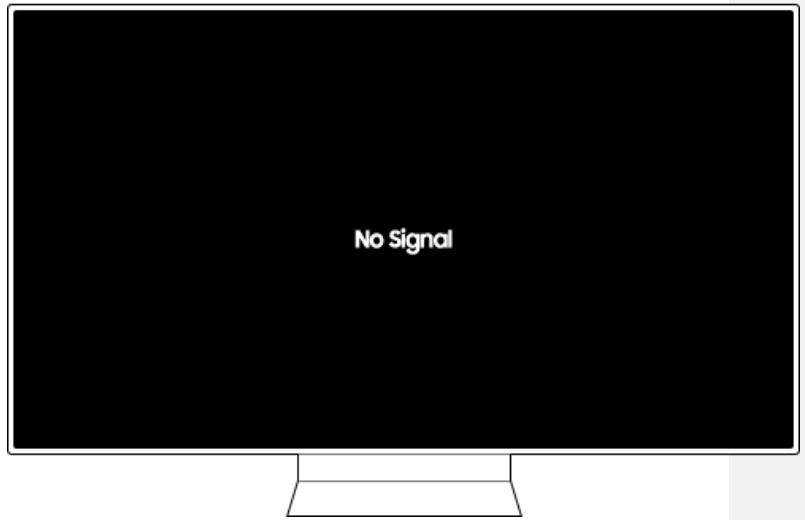
Background

Typical RISC-V SBC

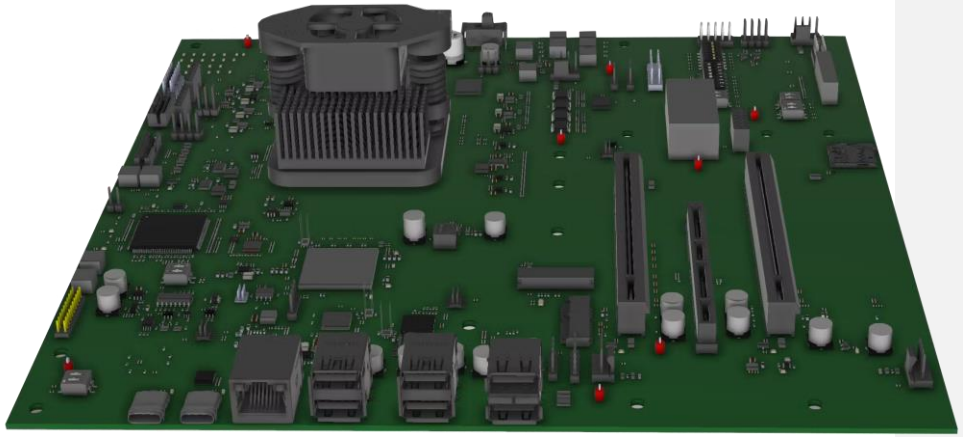
Off-the-shelf PCIe adapter (NIC/IPU, GPU, RAID)



Nothing

Background

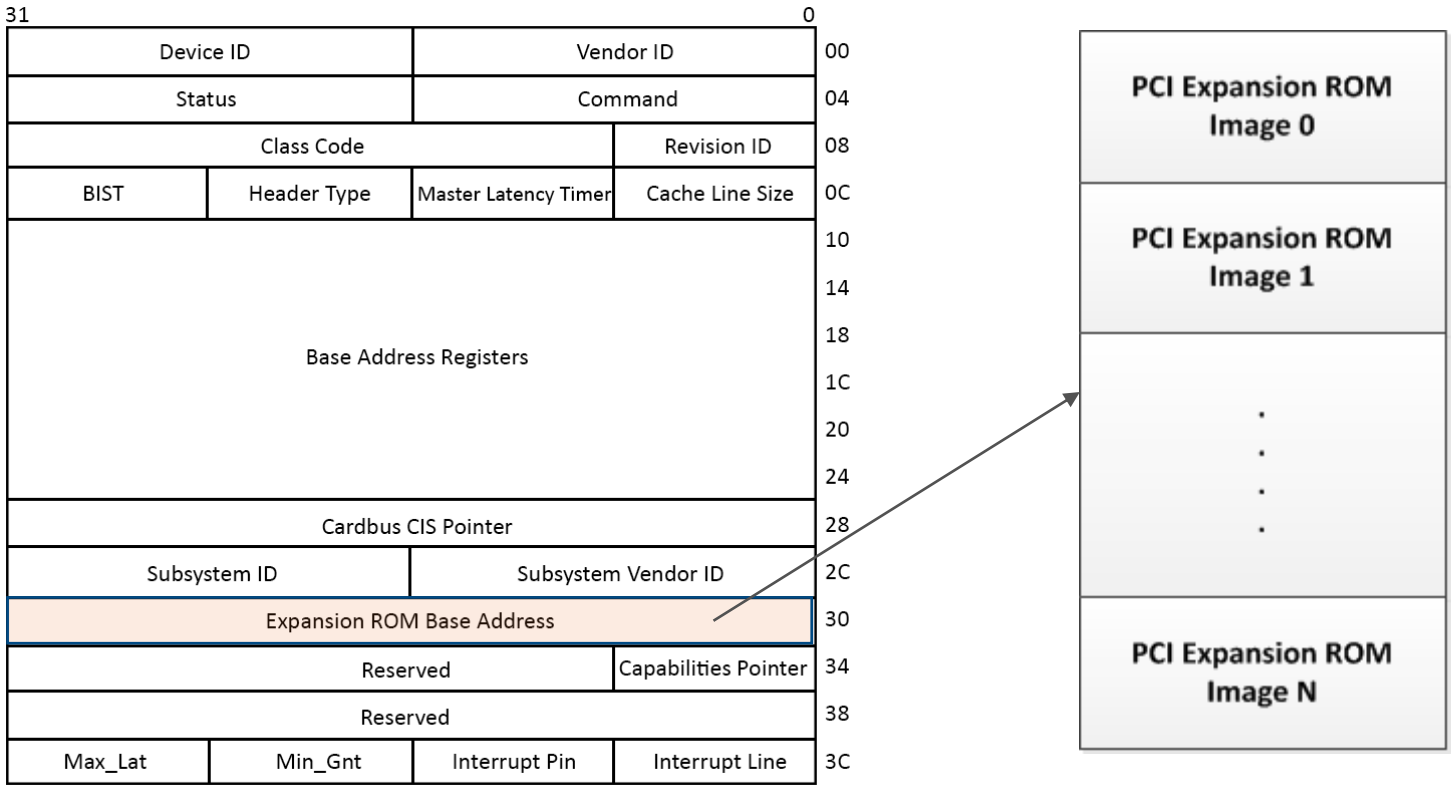
- **Today ➔** Non-standard RISC-V platforms, that don't lend to building to horizontal market segments where interoperability is key.
  - Single-vendor.
  - Embedded hardware with little extensibility.
  - Embedded firmware and OS with all the drivers baked in.
  - "I plugged a PCIe NIC in, but couldn't figure out how to network boot my OS"
- **Tomorrow ➔** An interoperable RISC-V ecosystem that allows building servers and PCs.
  - Many vendors come together for a solution.
  - PCIe/CXL connectivity for off-the-shelf devices.
  - Rich UEFI + ACPI firmware experience.
  - Same OS image can boot across different platforms, SoC, IP implementations.



How to make existing PCIe devices work?

Will future PCIe devices ship with RISC-V firmware drivers?

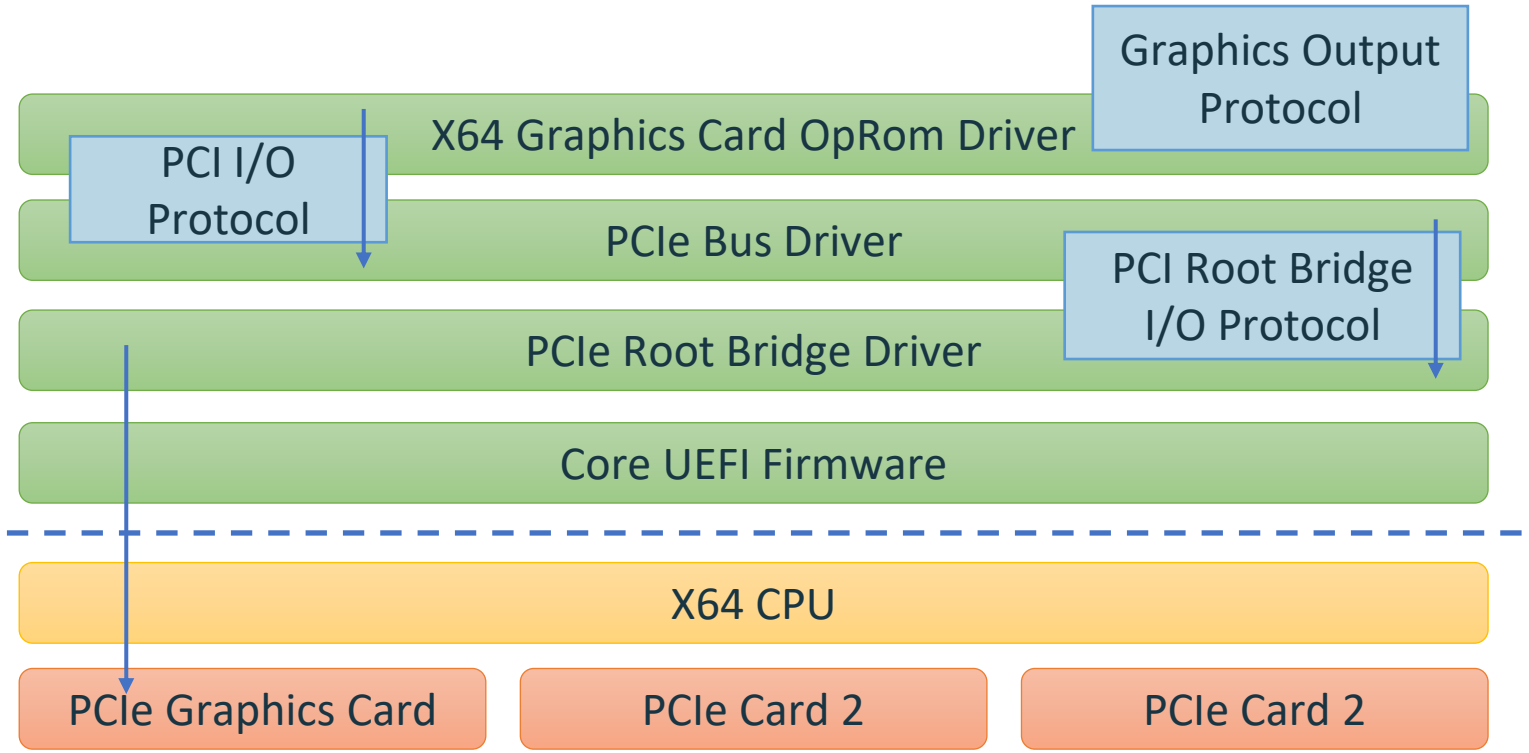
PCIe Firmware Drivers



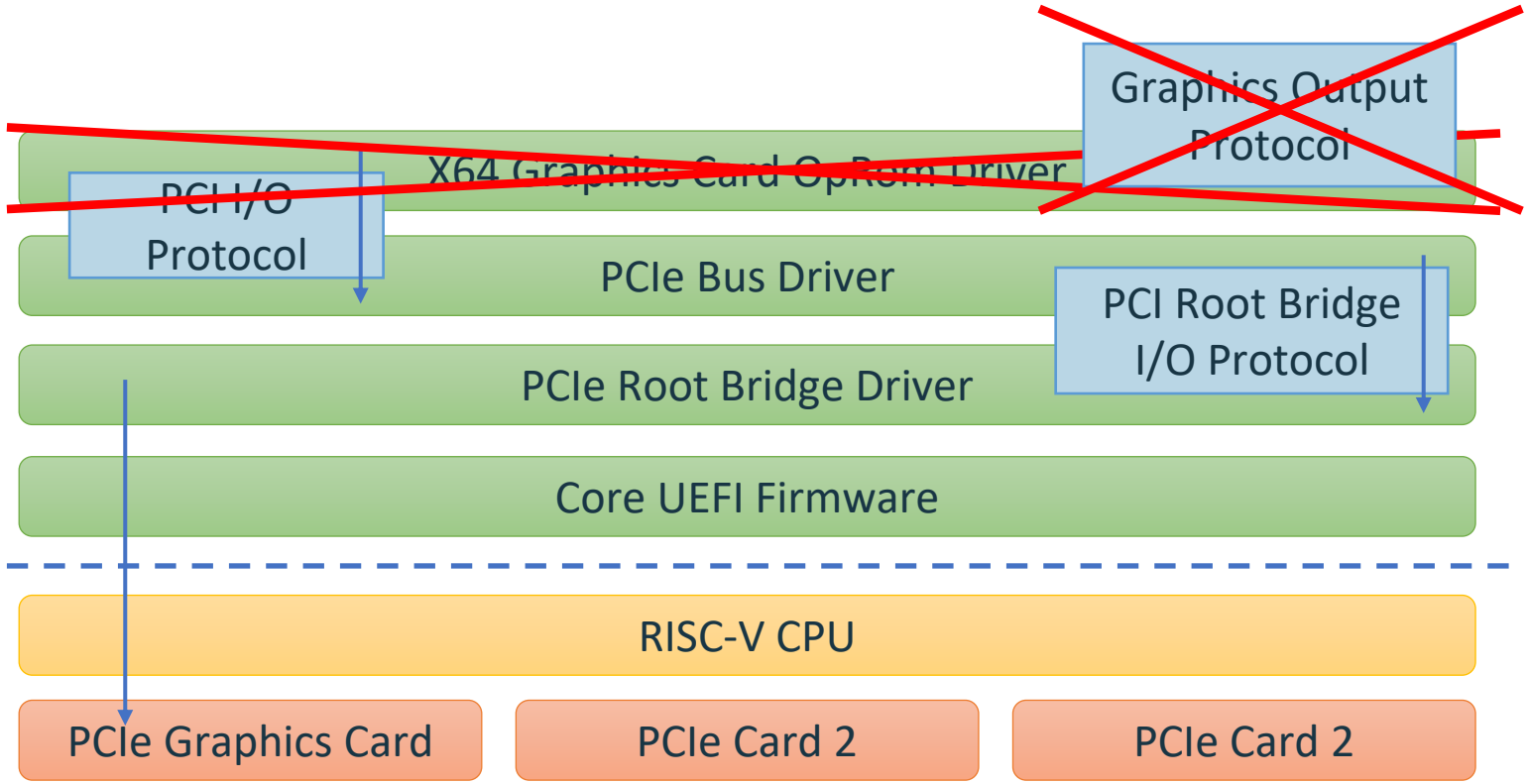
Legacy PC-AT BIOS ROM

X64 UEFI Driver

Life of PCIe in UEFI



Life of PCIe in UEFI on RISC-V



Hasn't this been solved before?

Legacy PC-AT BIOS ROM

X64 UEFI Driver

EBC UEFI Driver

EFI Byte Code

- ☑ Specifically made for this scenario!
  - Processor Independence
    - sizeof(VOID*) is a runtime operation.
    - VM takes care of 32 vs 64 vs 128-bit issues.
  - TianoCore comes with an interpreter.
- ✗ Not used by the industry!
  - No tooling – the only supported and proprietary C compiler has been retired.
    - Some OSS now exists
      - https://github.com/yabits/ebcvm / ELVM
      - https://github.com/pbatard/fasmg-ebc
  - Different performance profile - interpreted code.
  - Didn't make a come-back when the Arm ecosystem explored this space

How did the Arm ecosystem solve this?

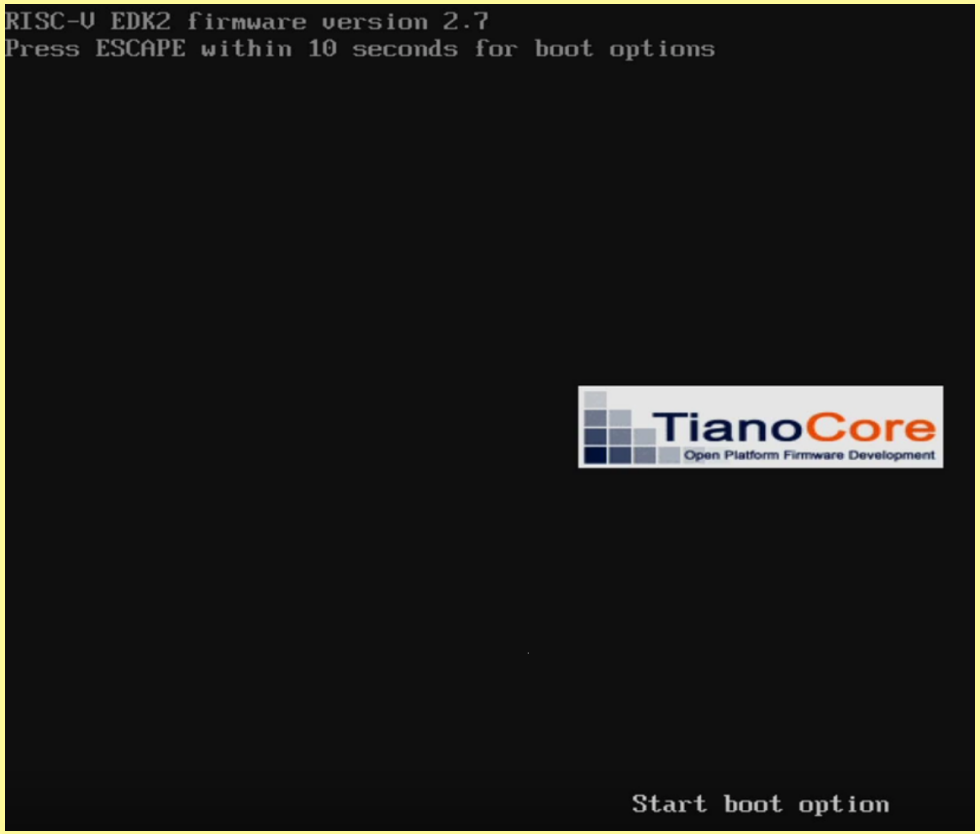
X86EmulatorPkg

- ☑ Supports x64 OpRoms and UEFI applications on AArch64 systems.
  - Open Source UEFI Boot Service Driver
  - Targets 64-bit AArch64 systems (servers, workstations)
  - Developed by Linaro engineers 6 years ago.
  - Uses Qemu Tiny Code Generator for efficient translation of x64 to AArch64 code.
  - https://github.com/ardbiesheuvel/X86EmulatorPkg
- ✗ Not trivially portable to RISC-V!
  - Old TCG code of unknown provenance.
  - Backporting RISC-V support sounds hard (and time consuming) unless you're a Qemu guru.

MultiArchUefiPkg

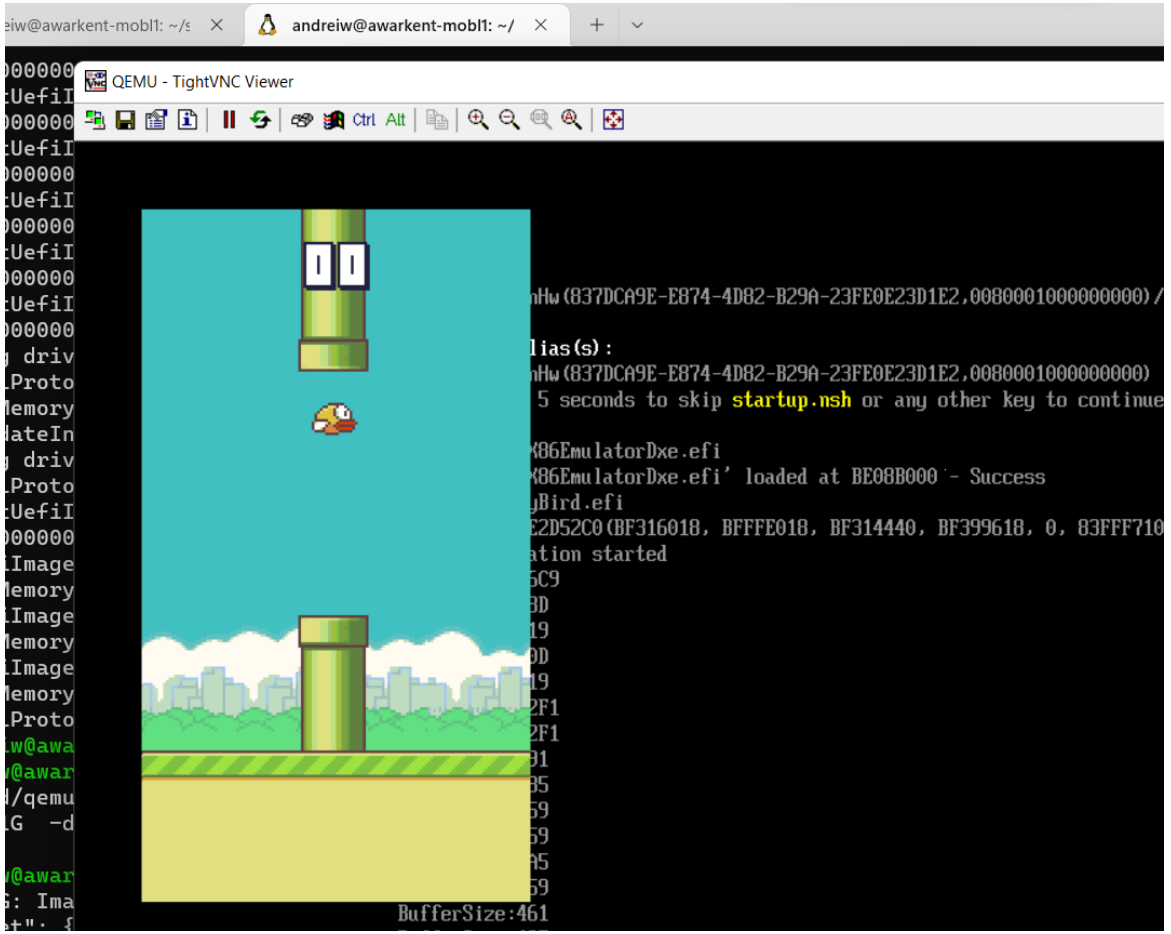
Rewrite of X86EmulatorPkg

- Portable: Supports AArch64 and 64-bit RISC-V UEFI hosts.
- 64-bit x64 and AArch64 UEFI Boot Service emulation.
- Clean: Abstracts Qemu/TCG with Unicorn Engine API.
- https://github.com/intel/MultiArchUefiPkg
- RISE Project in the Firmware WG
- Correctness, perf, size.




```
7D 0000000A B - -   1   6 Usb Bus Driver                                  UsbBusDxe
7E 0000000A D - -   1   - Usb Keyboard Driver                             UsbKbDxe
7F 00000011 D - -   1   - Usb Mass Storage Driver                         UsbMassStorageDxe
82 00014300 B - -   1   1 AMD GOP X64 Release Driver Rev.1.67 Offset(0x10000,0x1E5FF)
Shell> _
```

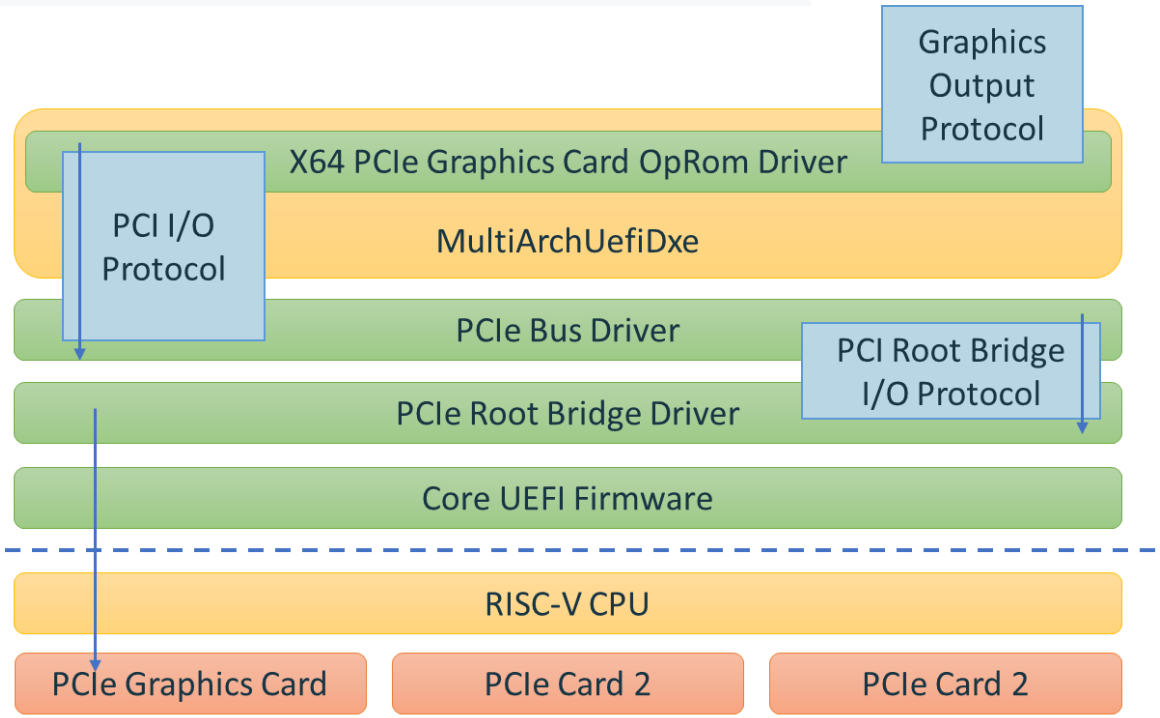
MultiArchUefiPkg



How it works

- Possible entirely due to narrowly-defined EFI ABI
- Models Boot Services environment, with certain services filtered or disabled.
- Tiano support for foreign binaries - EDKII_PECOFF_IMAGE_EMULATOR_PROTOCOL
- Emulation is only interesting if thunking goes both ways!
  - RISC-V No-Execute handler traps for native → emulated.
  - Unicorn No-Execute handler traps for emulated → native.

```
UINT64
EFIAPI
Fn(UINT64, UINT64, UINT64, UINT64,
   UINT64, UINT64, UINT64, UINT64,
   UINT64, UINT64, UINT64, UINT64,
   UINT64, UINT64, UINT64, UINT64);
```



Now what?

- Fine for short term.
  - Tons of “correctness” or validation issues https://github.com/intel/MultiArchUefiPkg/issues
  - More testing on real RISC-V hardware.
  - UEFI MMU patches from Ventana Micro in soon.
- What about long term?
  - Existing ISAs are a moving target.
  - OpRom environment unconstrained.
- Multiple ISA support in COTS hardware unlikely.
  - How many adapters ship with x64 + AArch64 today?
  - How many will additionally bundle RISCV64, RISCV128 and LOONGARCH support?

!!! NEED YOUR FEEDBACK !!!

- Embrace emulation, but how?
  - Resurrect EBC.
    - Never been more relevant with 4 64-bit ISAs and 128-bit ISAs following.
    - Tooling
    - Performance
  - Constrain x64 OpRom environment.
    - Meet IHVs half-way.
    - Pick a subset of x64– ring3, basic SSE, etc.
    - Generate code that will guarantee to run via MultiArchUefiPkg.
  - WASM for EFI.
    - Great tooling.
    - Sandboxing?
    - 128-bit support?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