2025 DESIGN AND VERIFICATION™ DVCON CONFERENCE AND EXHIBITION UNITED STATES

SAN JOSE, CA, USA
FEBRUARY 24-27, 2025

Leverage Real USB Device For USB Host DUT Verification

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Agenda

- Introduction – Transactor based Verification for Protocol Interfaces
- USB Subsystem (in real world)
- Enabling USB Host DUT Verification in Virtual Framework
- Questions

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Introduction

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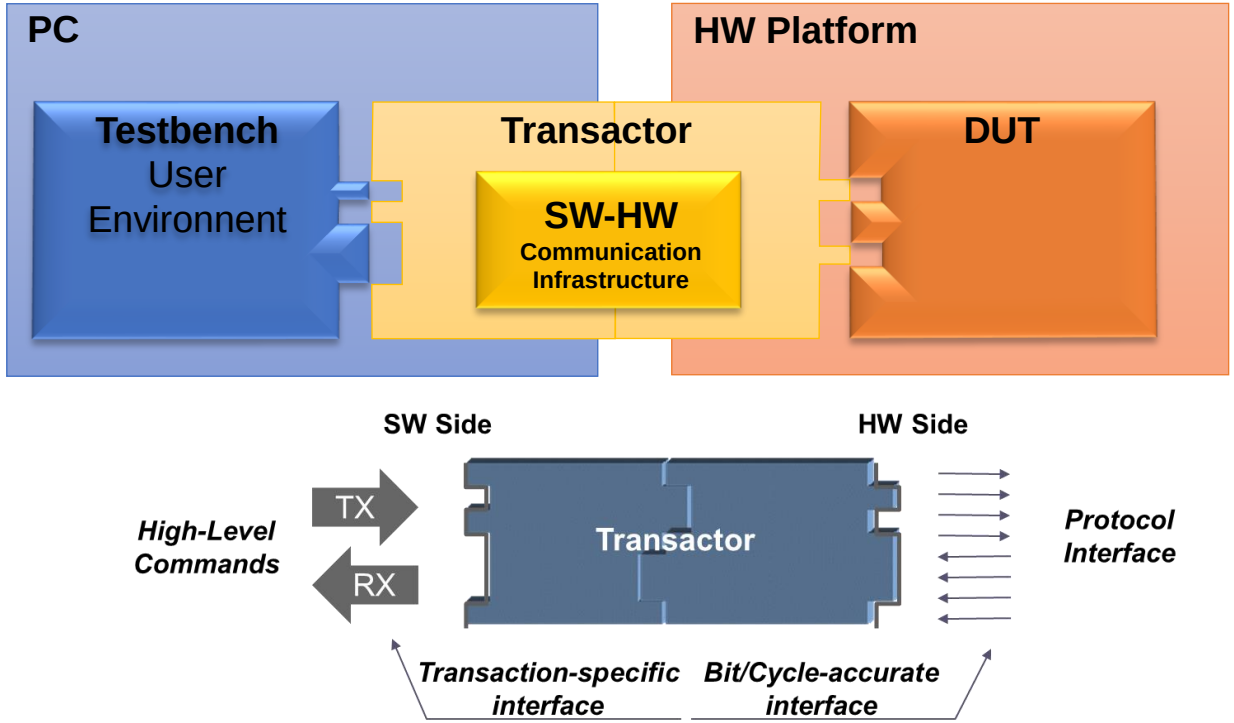
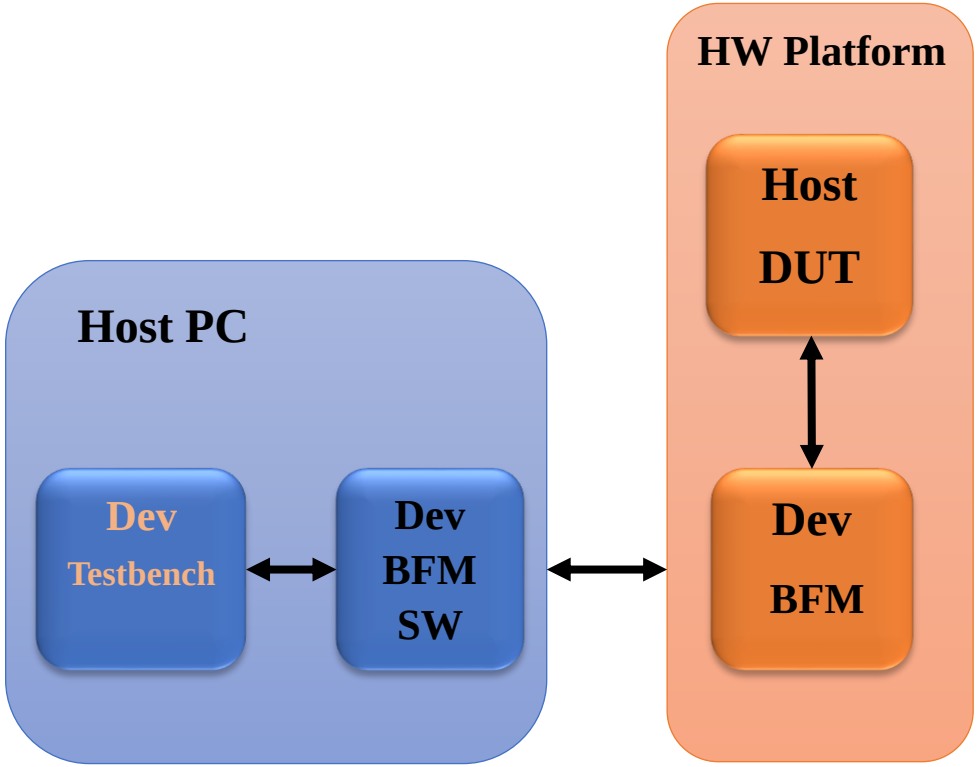
Transactors and Transactor based verification

- Transactor : Bridge between Testbench and DUT.
  - Software side : Provides high-level APIs to perform protocol-specific actions
  - Hardware side : Matches the specific protocol interface with DUT at cycle/bit level
- User level Testbenches model the actual traffic across the protocol Interface

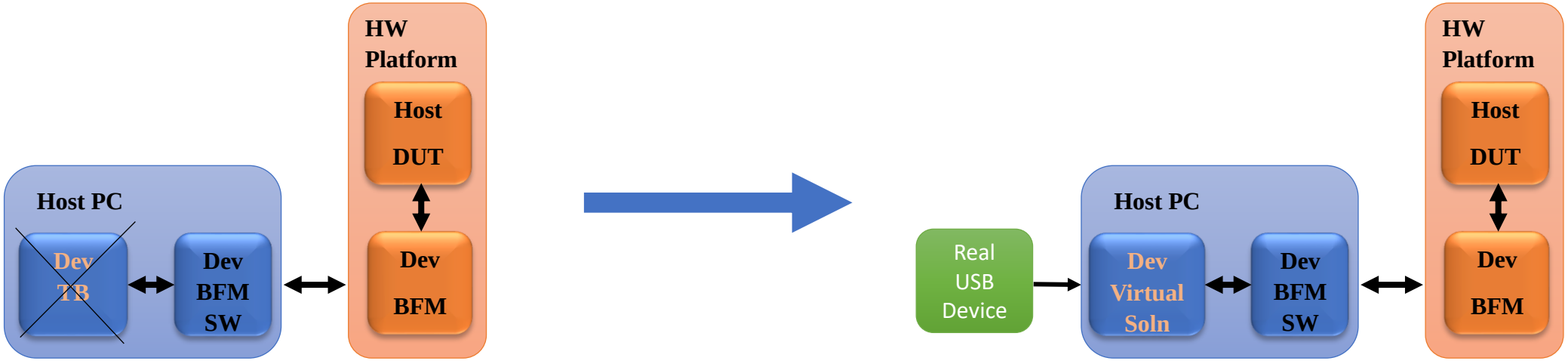


USB Host DUT Verification Environment with Device Testbench



- Requirement to model traffic for a USB devices requires a complex User Testbench
  - USB -- 21 Device classes (mapped to different devices)
    - Multiple Sub classes
    - Multiple protocols Variants
  - Multiple Person months of efforts, prone to user errors
- **How can we reduce this complexity?**

USB Host DUT Verification with real USB device



What if, Real USB device acts as a Device Testbench?

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USB subsystem (in a real world)

Interaction with Linux and libusb

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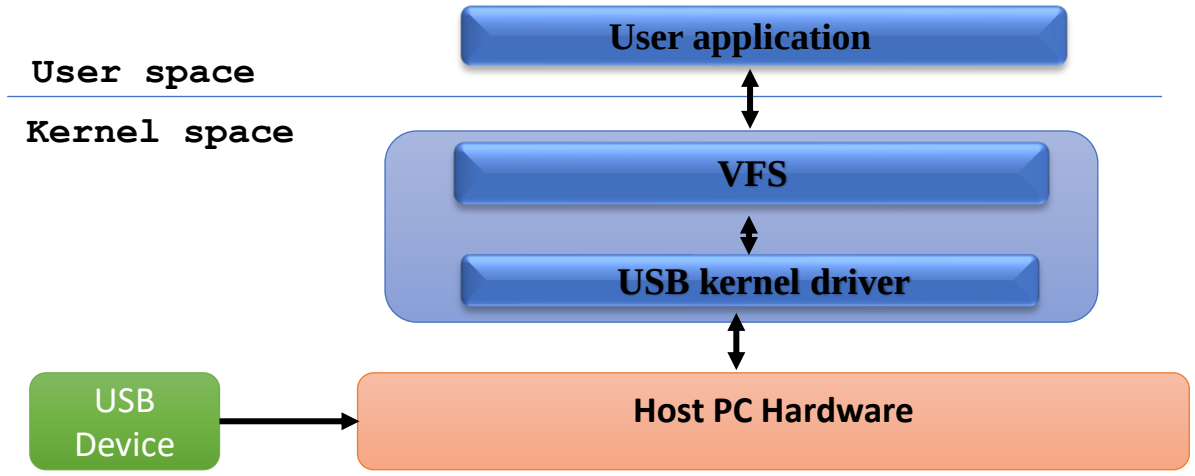
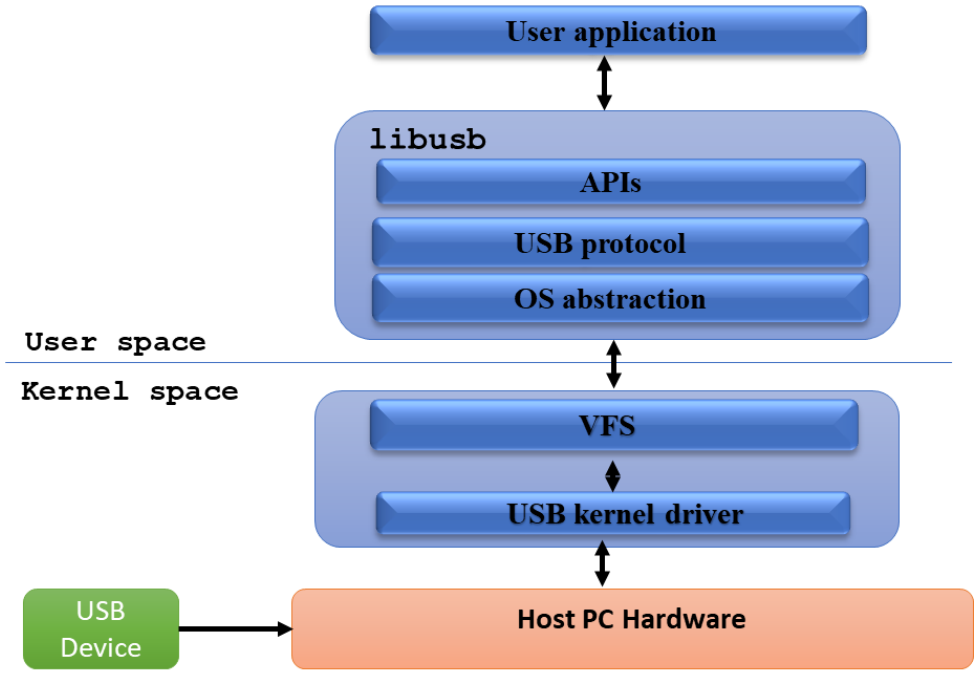
USB Subsystem in Linux framework



- USB device is inserted
- Kernel detects USB device.
  - Invokes USB Host driver
- USB Host driver creates data structures for user drivers.
- User drivers are created.

‘libusb’ and its role



- Libusb
  - Open source Linux library in C
  - Encapsulates OS and USB protocol complexities.
  - Provides simpler APIs
  - APIs allow device driver development in user space.

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Enabling USB Host DUT verification with Actual USB devices in a Virtual framework

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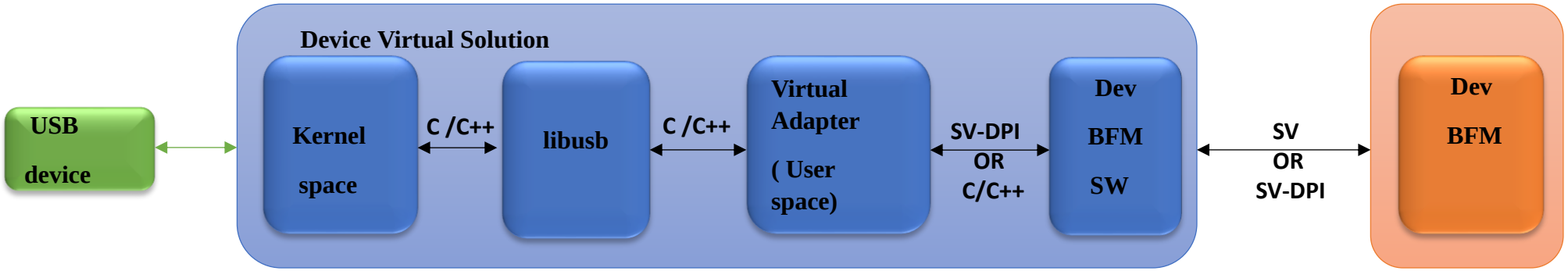
Device Virtual Solution



- Leverage Linux Kernel framework and libusb to connect Device BFM SW with real USB device.
- Create Virtual Adapter (User mode driver) that connects Device BFM SW with real USB device.
- Developed virtual solution for mass storage class, Bulk-Only-Transport protocol.

Virtual Adapter (User mode driver)

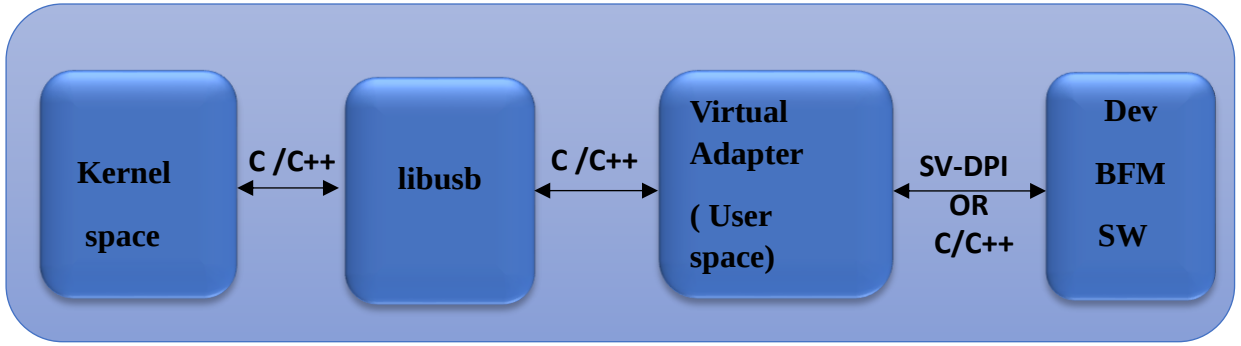
- Create a virtual adapter (user mode driver) in C.
- Include `libusb` header.

```
#include "libusb.h"
```

- Initialize `libusb`.

```
libusb_context* m_libusbContext;

ret = libusb_init(m_libusbContext);
```



- Connect `libusb` with USB device.

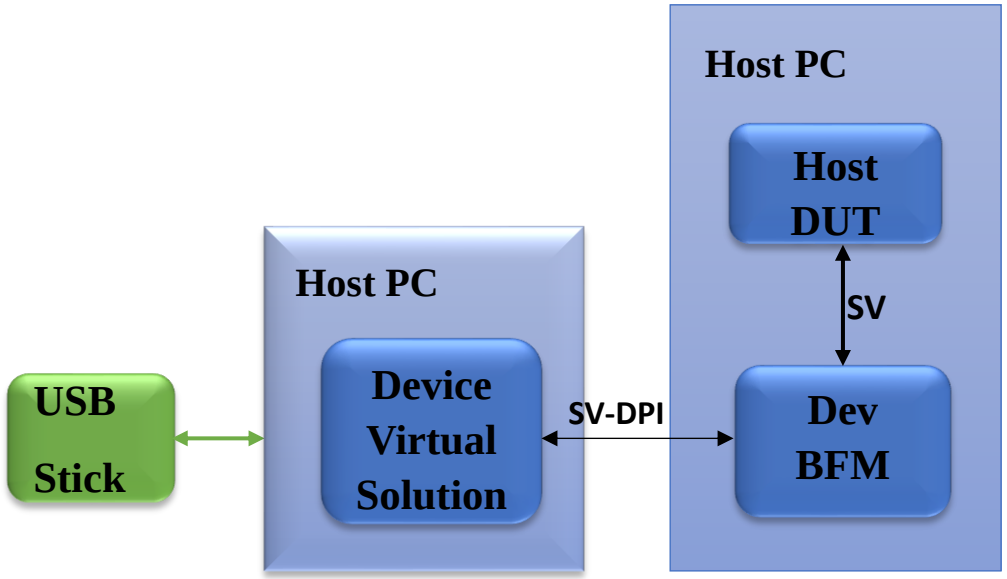
```
m_libusbHandle =
libusb_open_device_with_vid_pid(m_libus
bContext, VENDORID, PRODUCTID);
```

- Interact with USB device using libusb APIs.

Host DUT verification in Virtual framework

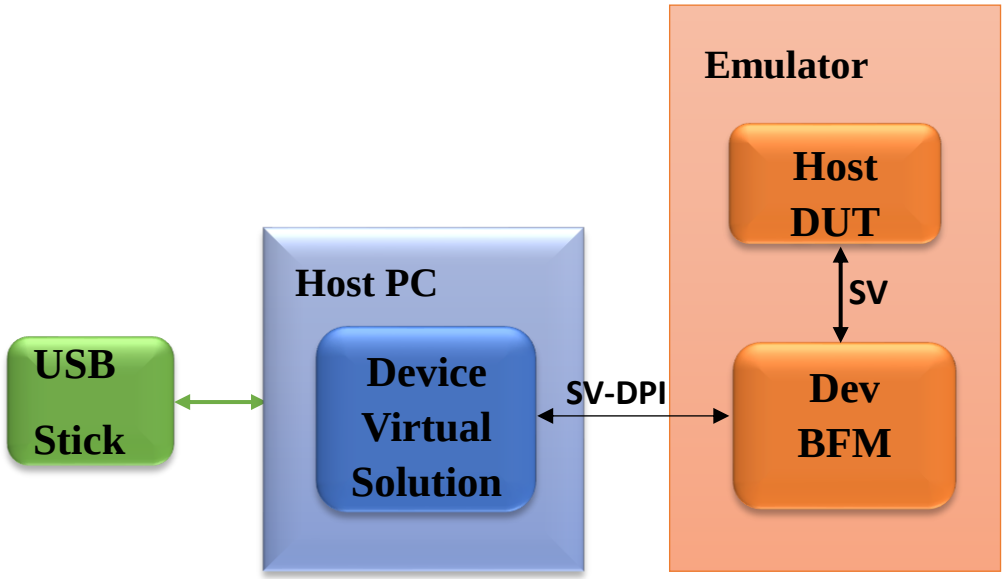
Simulation Verification Env

DUT and BFM are on Host PC



Emulation Verification Env

DUT and BFM are on Emulator



Host DUT - Device Virtual Solution Integration

- Host DUT – Device Virtual Solution DUT BFM integration
  - Integrate and Compile USB Host DUT and Device Transactor on hardware platform.
- Testbench Environment Settings
  - Connect a real USB mass storage device in Host PC.
  - Obtain USB real device vendor ID and product ID. Use `lsusb`
- Device Virtual Solution Testbench
  - Use Device Virtual Solution APIs to connect with real USB device
  - Run a Device Virtual Solution service loop

Host DUT – Device Virtual Solution at Runtime

- Wait for link up between Host DUT and Device transactor hardware.
- Host DUT enumerates real USB device.
  - Device Virtual Solution responds to control transfers through USB real device.
- Host DUT initiates' traffic.
  - Device Virtual Solution responds to transfers through USB real device.

Verification Results and Future Work

- Verification Results
  - HS (SS) mass storage device were inserted insert in Host PC
  - Host transactor enumerated Device virtual solution
  - Ran few SCSI commands, transferred and received 1800K (3600K) bytes from HS(SS) device.
  - At HS speed, In simulation, test completed in 5702 seconds, while in emulation it completed in 23 seconds (248 times faster)
  - At SS speed, In simulation, test completed in 4815 seconds, while in emulation it completed in 16 seconds (301 times faster)
- Future Work
  - Enhance solution for other device classes, sub classes, and protocols.
  - Similar approach can be taken for other protocols, and timers.

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Questions

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Questions

- Thanks for joining!
- Feedback and offline questions:
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