A Brief Intro to xHCI Driver Model

Xiaofan Li -- xli2@andrew stuff

Agenda

- USB Background
- xHCI Architecture
    - Transfer overview
    - TD (Transfer Descriptor)
- xHCI on FreeBSD
- Proposed xHCI on Plan 9

Not talking about...

- USB init/attach/detach sequence
  - It’s boring
  - Just read the steps in manual
  - Many are irrelevant to driver writer e.g. MSI-X
- Power management
  - Oh my..
  - No..
- Different modes of the same operation
  - Implementation detail
  - Many modes do the same thing but some are more efficient sometimes
- Slot and endpoints
  - Important but complicated
  - Many data structure

USB Background

- SuperSpeed
  - 5Gb/s 10x over USB 2.0 (480Mb/s half duplex)
- More bandwidth
  - split bus
- Power management
  - U0 to U3 States
- Other new features
- USB 3.1 -- 10Gb/s … released in 2013

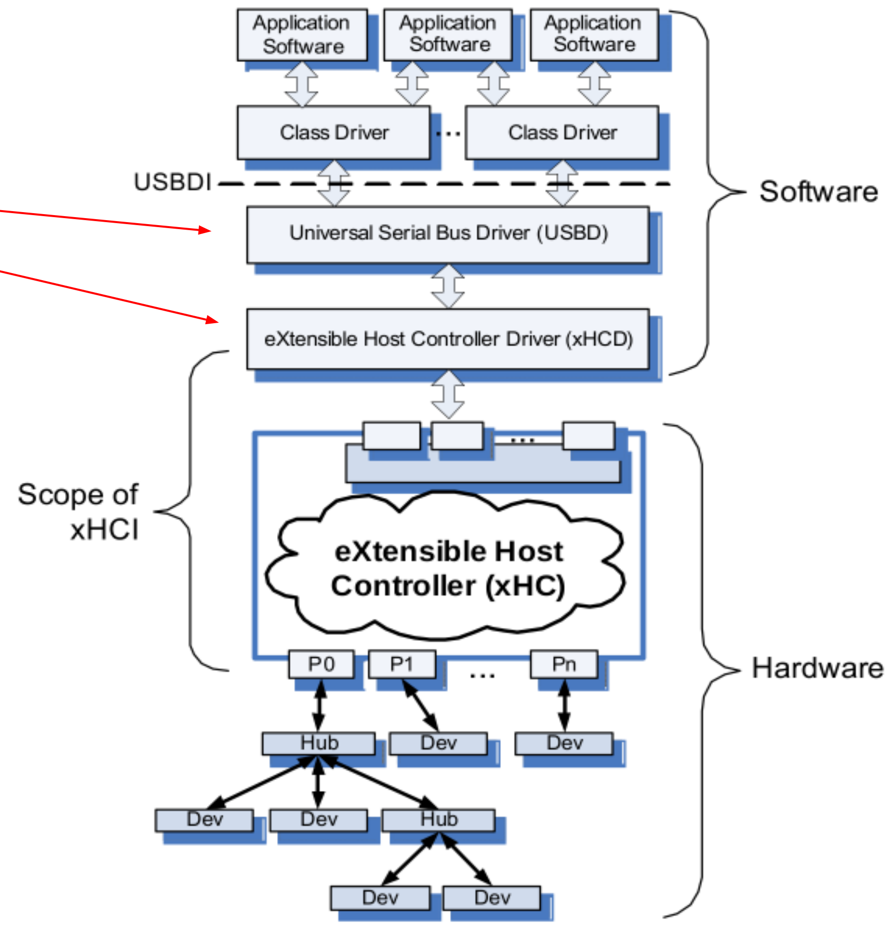
xHCI Architecture

We are focusing on

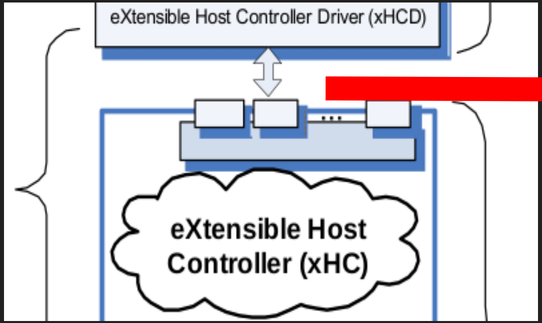
But...

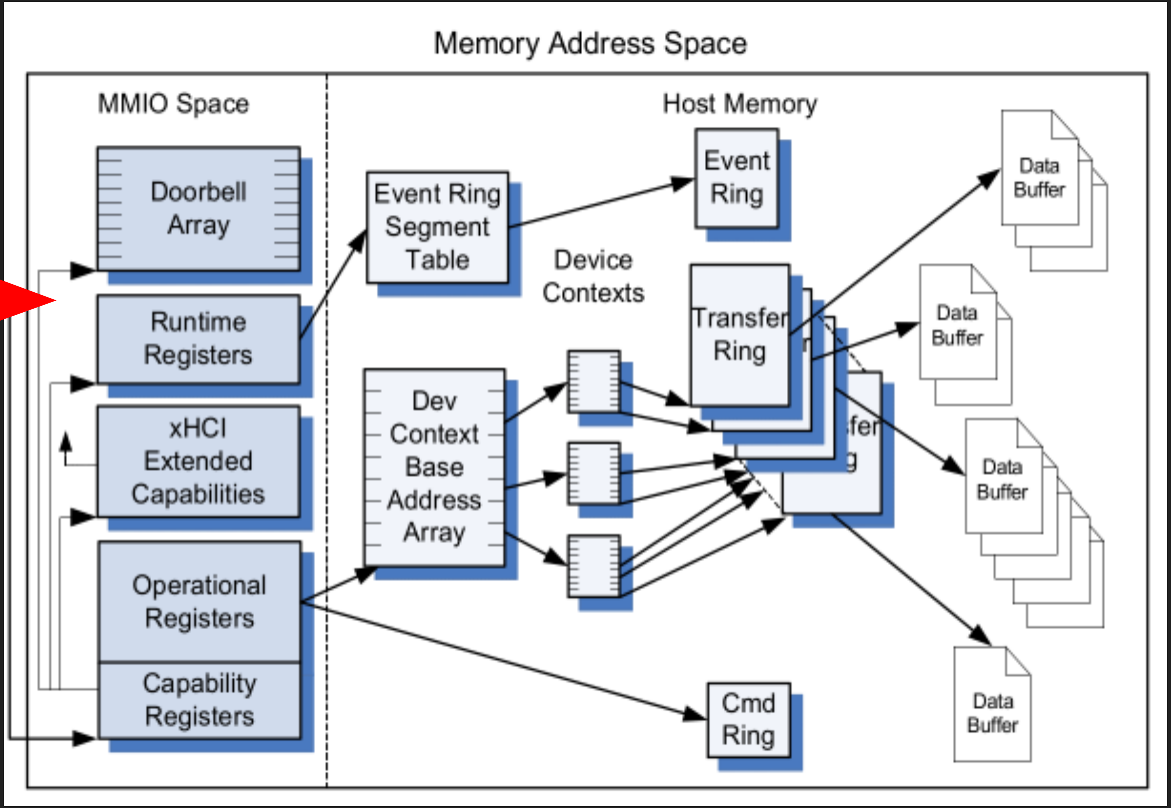
It’s nice to understand how the other parts interact with them

Figure 1: Universal Serial Bus, Revision 3.0 System Block Diagram

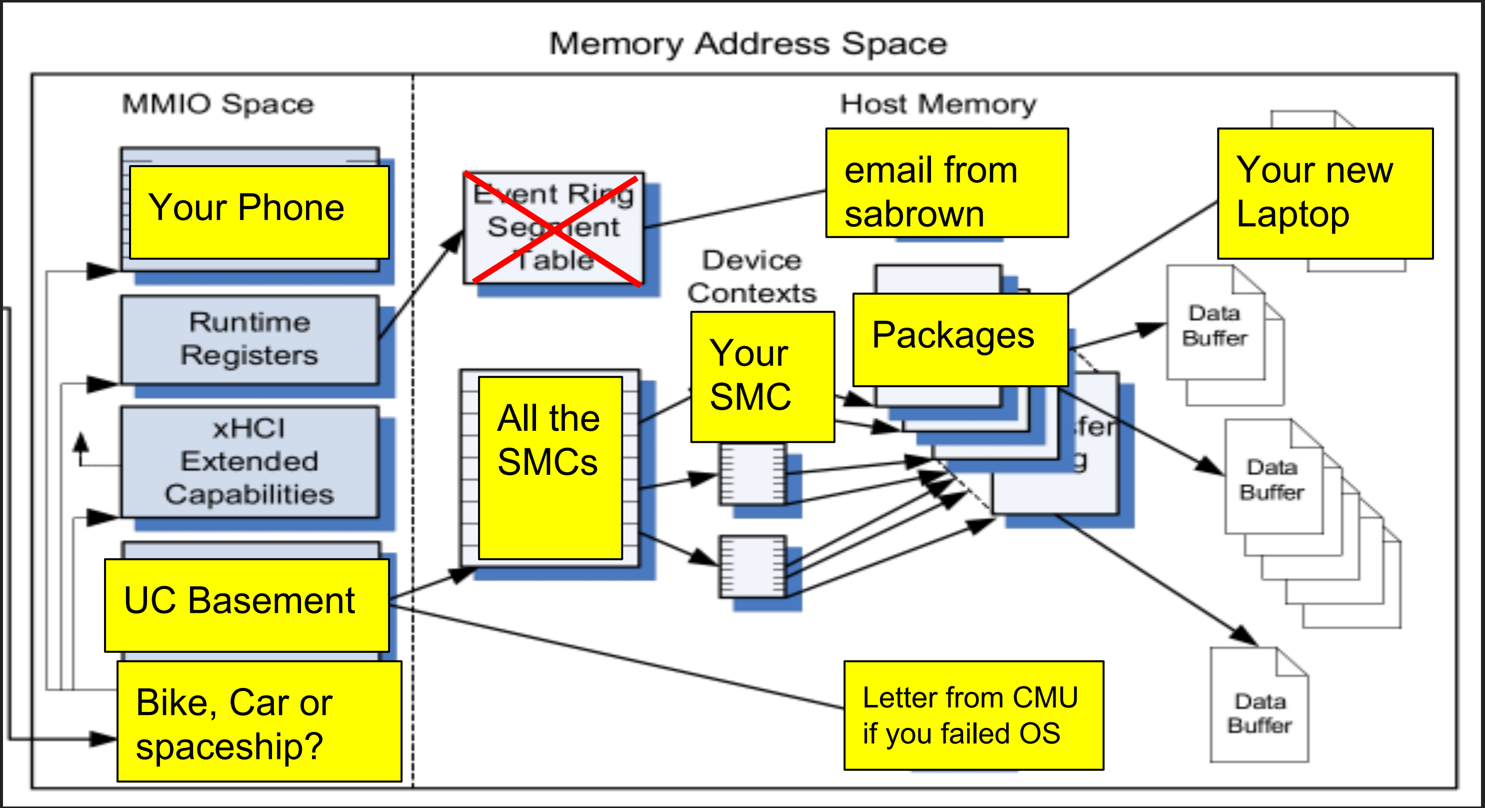


xHCI Architecture


eXtensible Host Controller Driver (xHCD)
...
eXtensible Host Controller (xHC)



xHCI Architecture

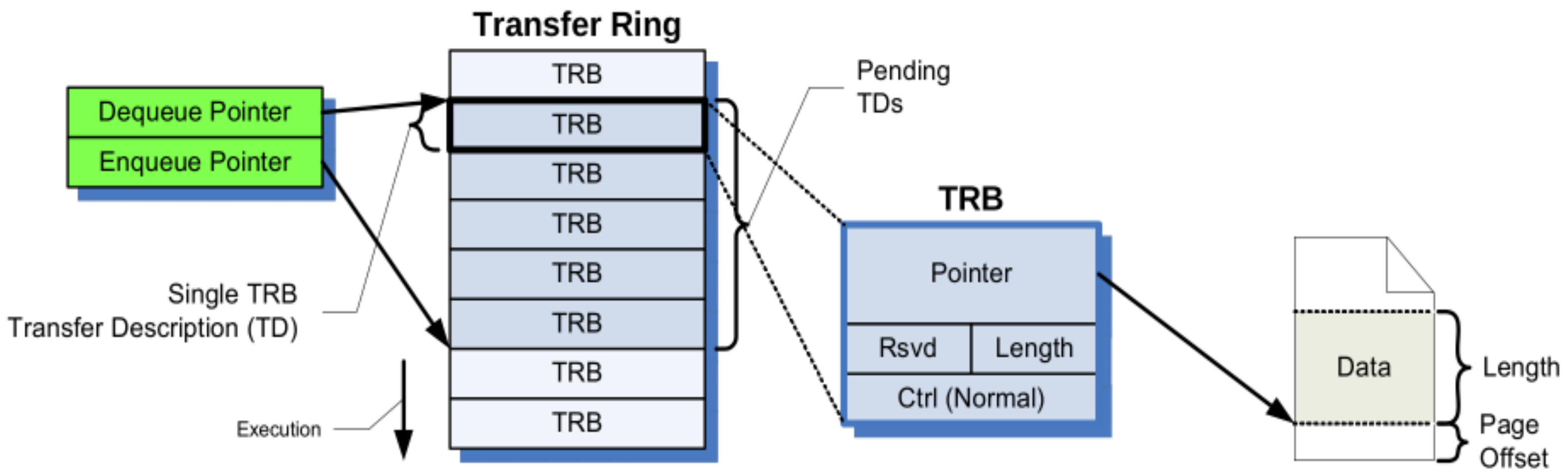


xHCI Architecture -- TD

- TD := Transfer Descriptor (aka “package”)
- TRB := Transfer Ring Block (aka “stuff in the package”)
  - Can reference physically contiguous data
  - Use chain bit for noncontiguous data
- Doorbell Register Array, aka “everyone’s phones”
- Uses ring structure so:
  - Enqueue Pointer
  - Dequeue Pointer

xHCI Architecture -- TD

Figure 5: Simple Transfer Example

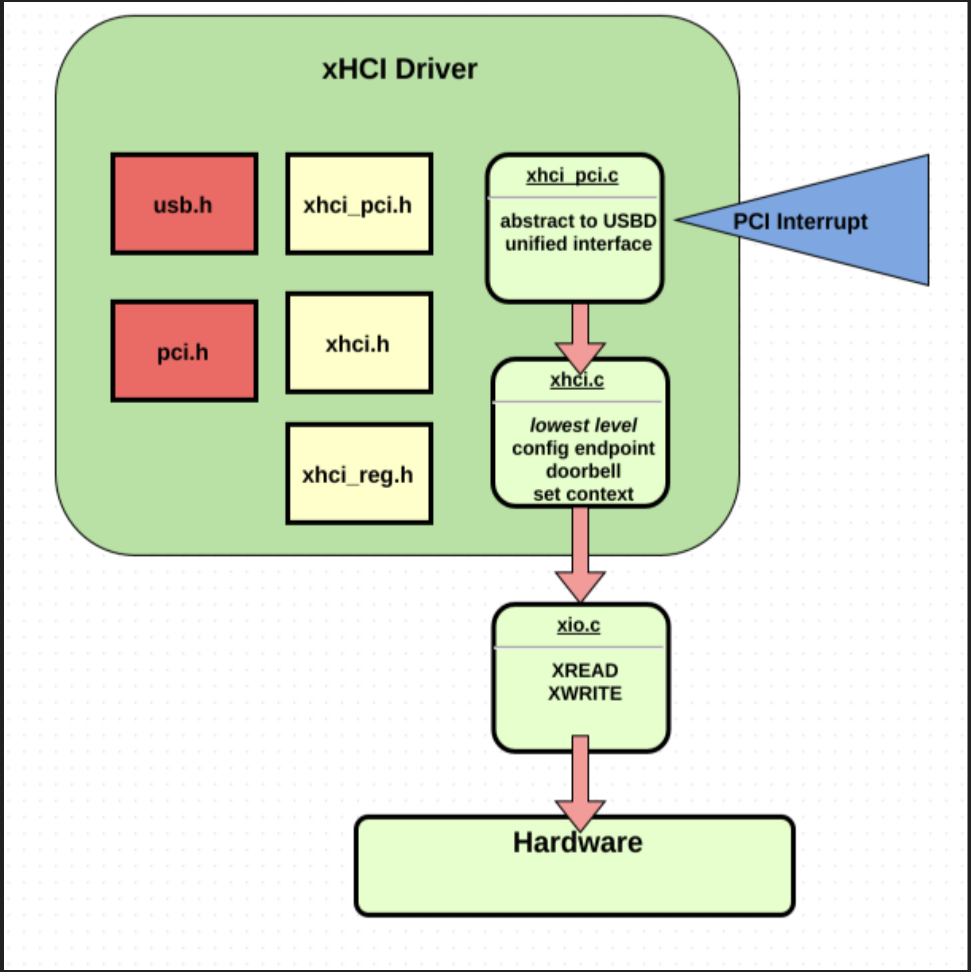


xHCI Architecture -- TD

- Many uses in the driver
  - Data Transfer
  - Control Transfer
  - Event Transfer
- Many Different modes
  - Periodic (Isochronous, Interrupt)
  - Asynchronous (Control, Bulk)
- Advanced supports
  - Scatter/gather of non-contiguous data (fall on different pages)

xHCI on FreeBSD

- usb.h and pci.h are generic interfaces.
- The driver writes TRBs to different contexts to communicate.
- PCI redirection used when new devices are attached.
- Interrupts passed through to xHCI handler after setup.



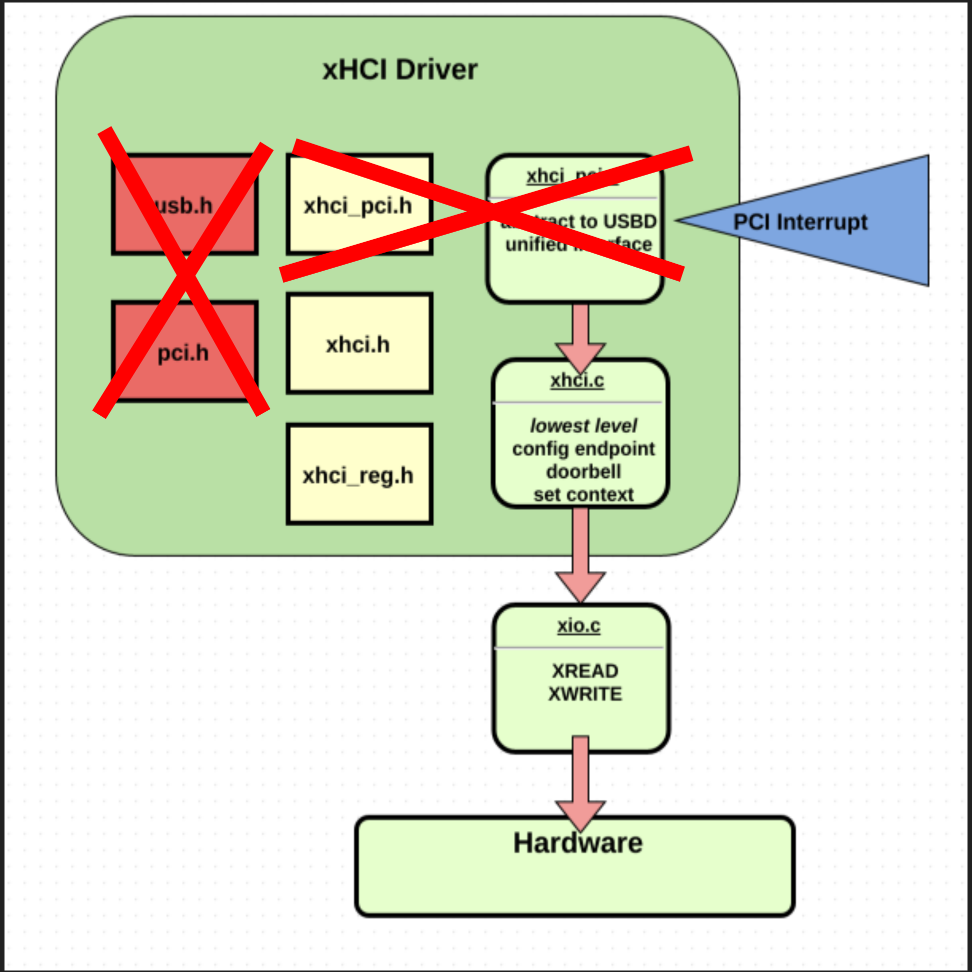
xHCI on Plan 9

What's different about Plan 9?

So, more "self-contained"...

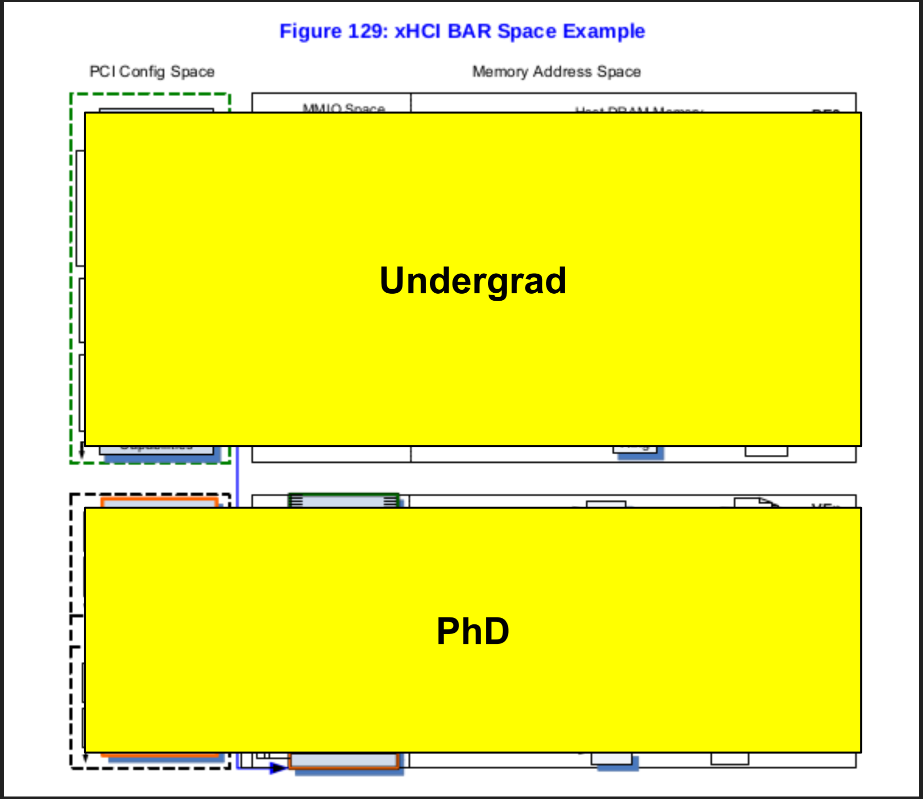
more educational..

less modular..



Where to go from here…

- Device Contexts
  - Input/output context
  - Slot context vs. endpoint context
- Register interfaces
  - Doorbell register arrays
- Rings
  - Event ring usage
- Scratchpad buffer array
- Extended capability
  - Power management
  - Virtualization support



Reference

Intel xHCI Manual: http://www.intel.com/content/dam/www/public/us/en/documents/technical-specifications/extensible-host-controler-interface-usb-xhci.pdf

FreeBSD on OpenGrok: http://bxr.su/

Plan 9: http://9p.io