



# A Process Oriented Approach to USB Driver Development



Fred Barnes and Carl Ritson, Systems Research Group  
Computing Laboratory, University of Kent, UK  
{ F.R.M.Barnes , C.G.Ritson } @kent.ac.uk

University of  
**Kent**

## Contents

- A brief introduction to occam- $\pi$
- The RMoX operating system
- USB hardware
- Process-oriented USB (in layers)
- Conclusions and further work

## A Brief Introduction to occam-pi

## A Brief Introduction to **occam-pi**

- ▶ **Process oriented** language: systems built from layered networks of communicating processes
  - semantics primarily from Hoare's **CSP** (communicating sequential processes)
  - incorporates ideas of **mobility** from Milner's  **$\pi$ -calculus**
- ▶ Language elements include:
  - **channels**: one-to-one, one-to-any, any-to-one, any-to-any synchronous unbuffered communication
  - **barriers**: synchronisation between multiple processes (CSP event)
  - **mobiles**: movement semantics for **data**, **channel-ends**, **processes**
  - **dynamic process creation**: for building dynamically evolving systems
- ▶ Strong **formal** concurrency mechanisms make **occam- $\pi$**  suitable for building many types of system, both simple and complex

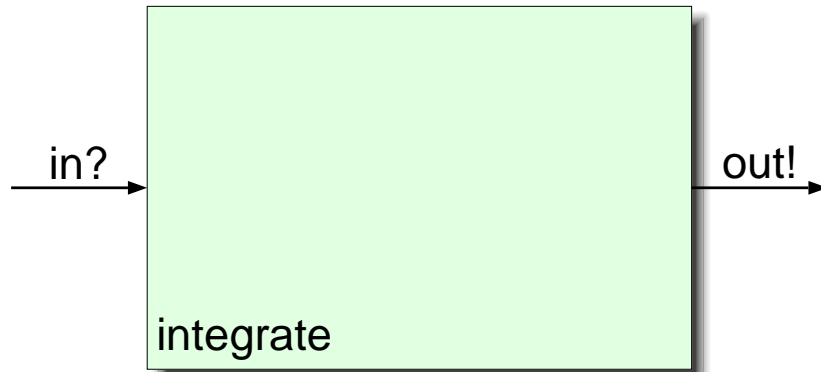
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PROC integrate (CHAN INT in?, out!)  
  INITIAL INT total IS 0:  
  WHILE TRUE  
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    SEQ  
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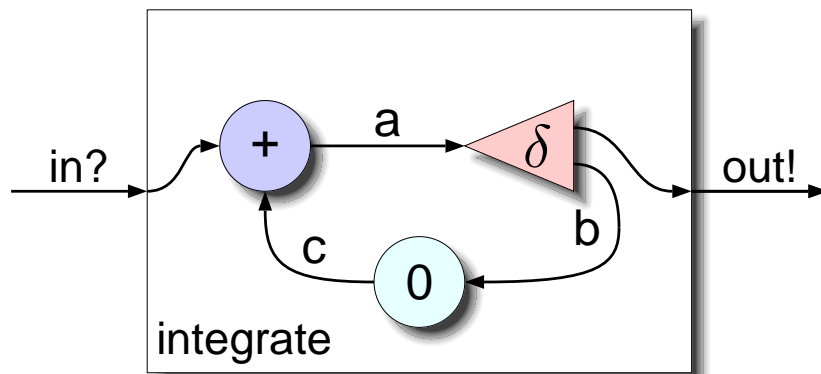


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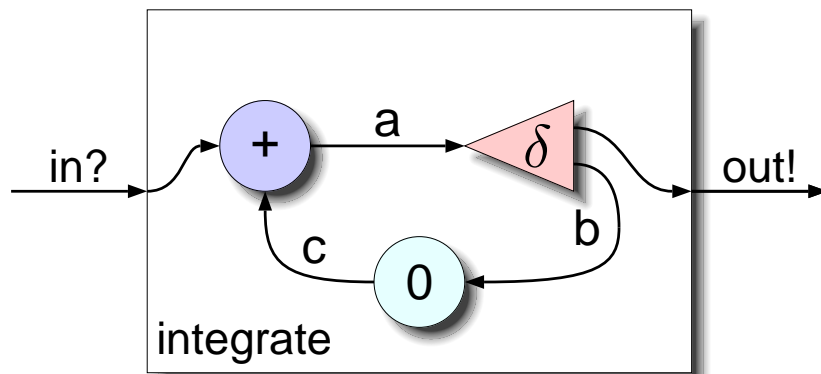
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PROC integrate (CHAN INT in?, out!)
  CHAN INT a, b, c:
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    plus (in?, c?, a!)
    delta (a?, out!, b!)
    prefix (0, b?, c!)
  :
```

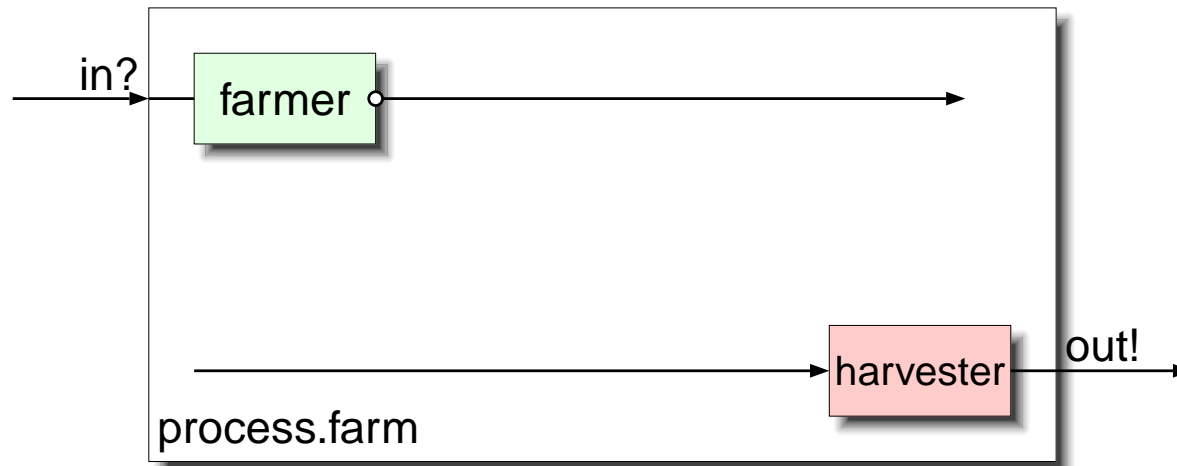
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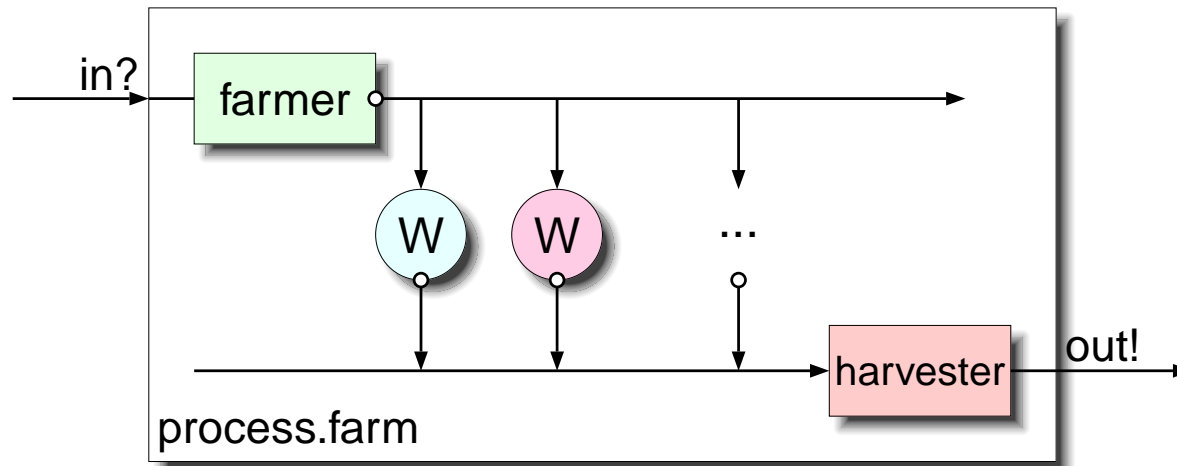
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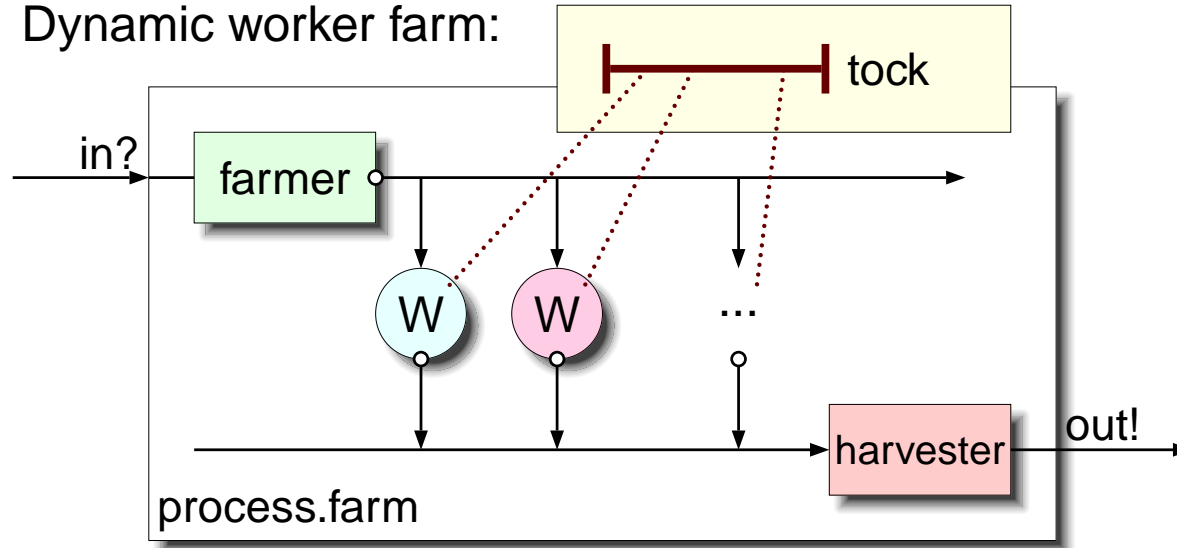
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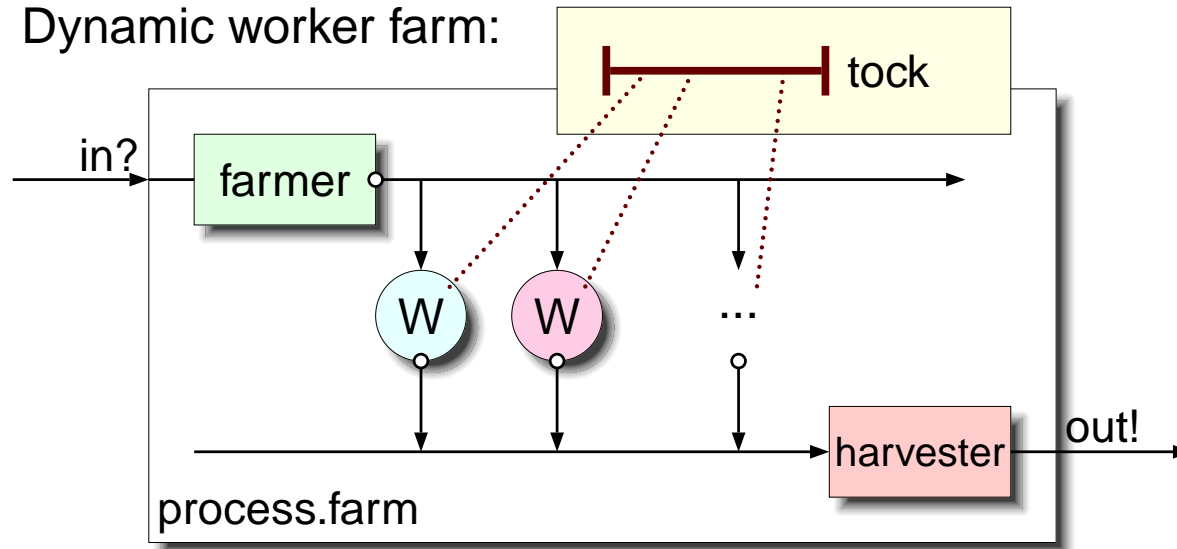
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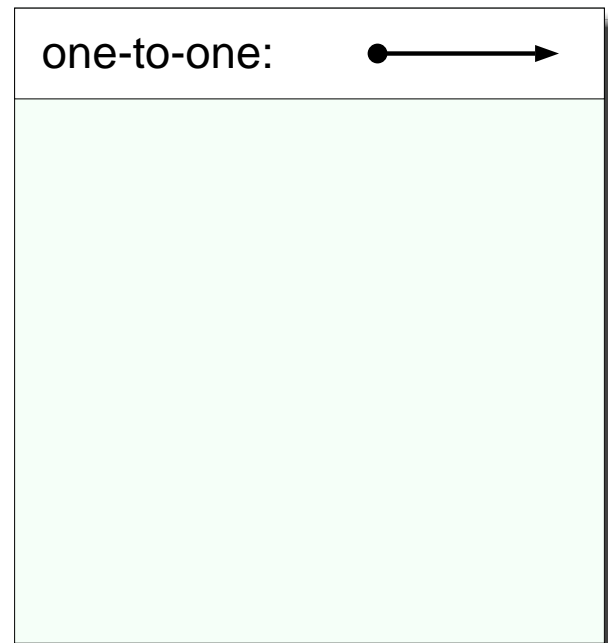
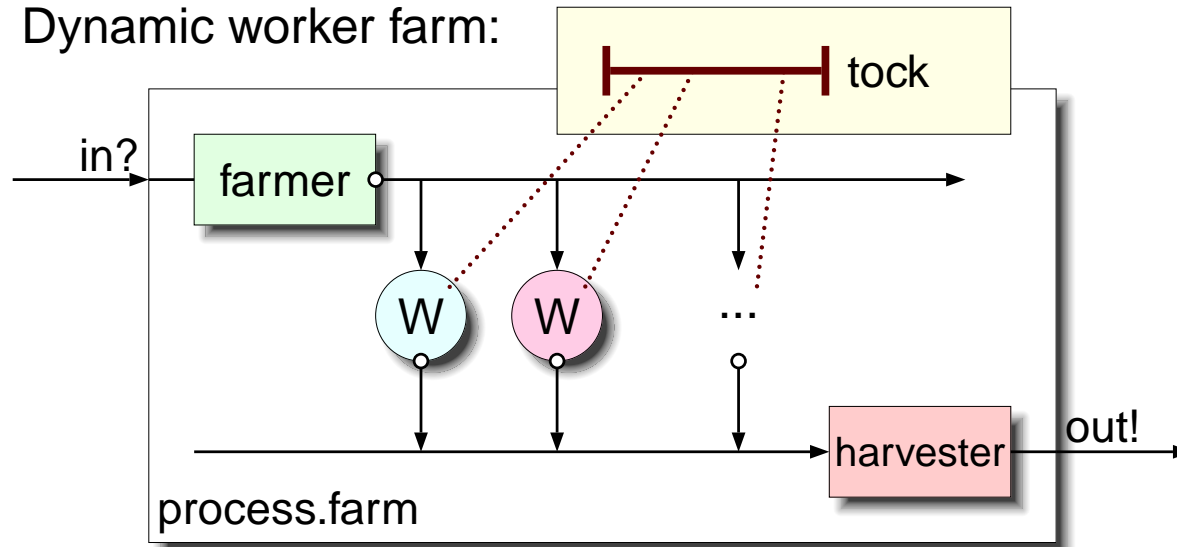


### ► Channel-type primer:

- bundles of channels declared as a **record-type**
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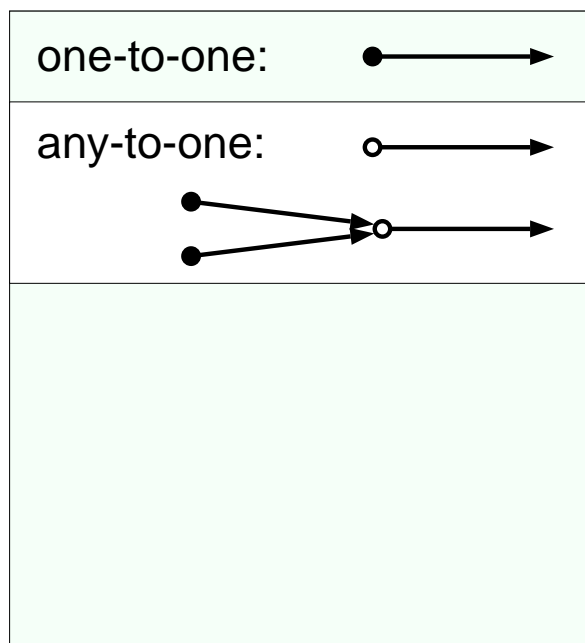
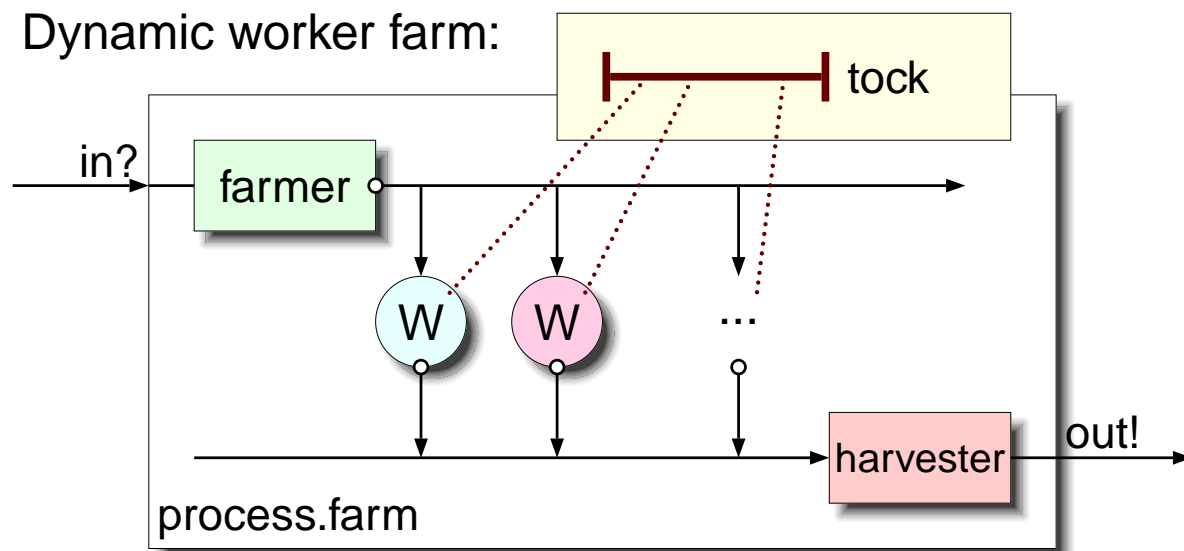
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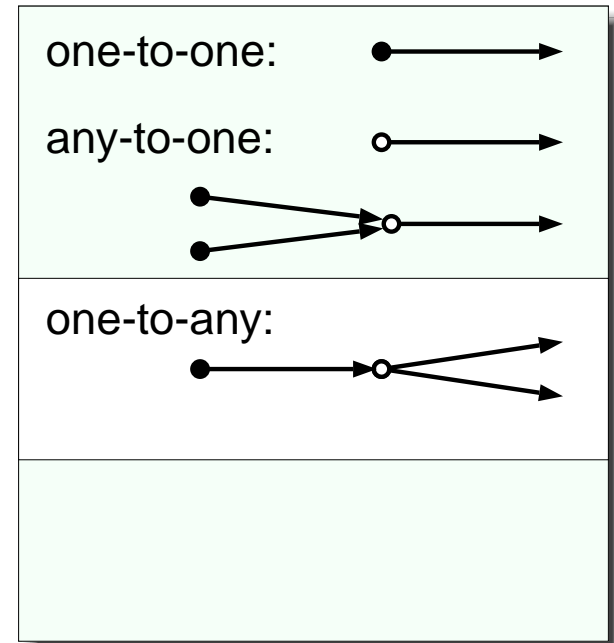
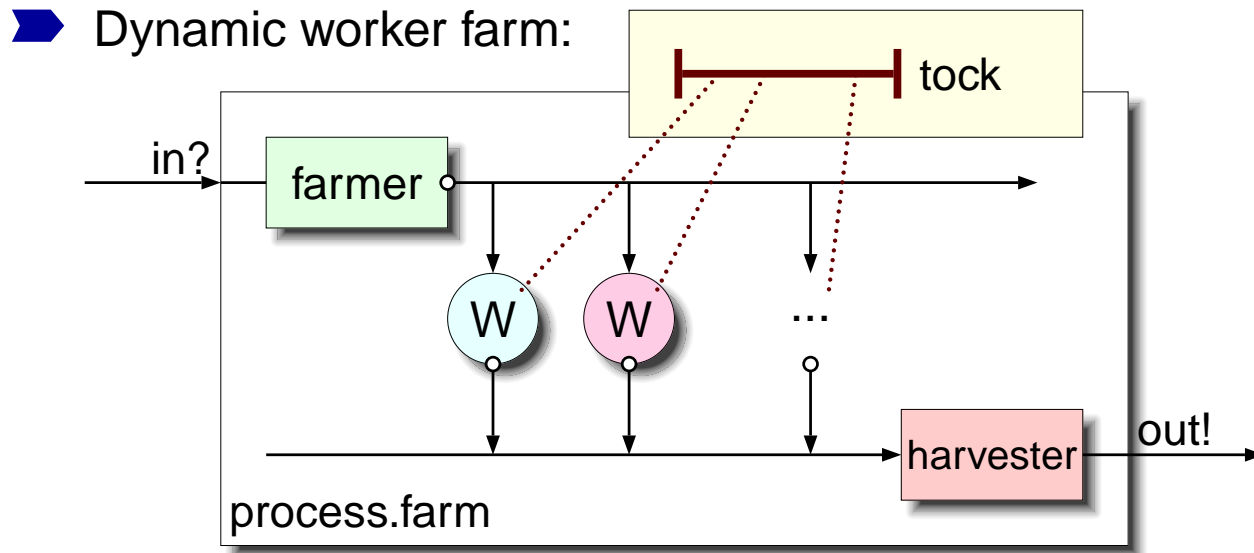


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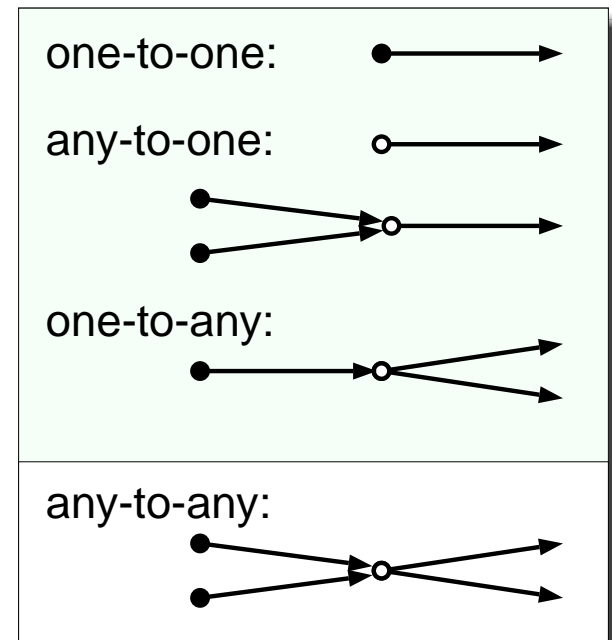
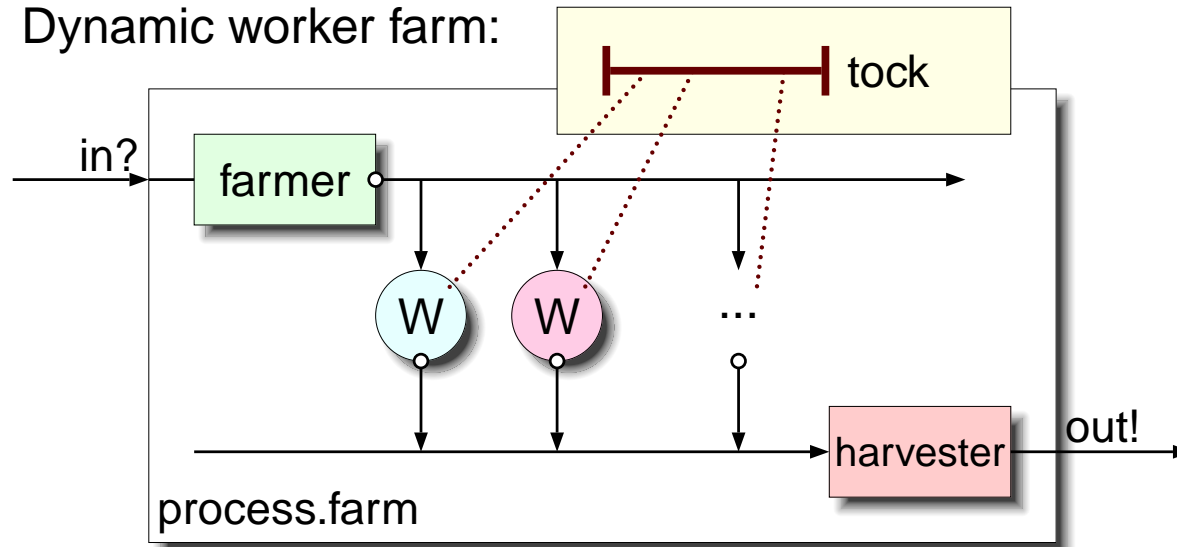
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  - similar things cropping up here and there (concurrent programming is of increasing interest, again)
- ▶ The memory footprint for occam- $\pi$  parallel processes is comparatively small:
  - can handle **millions** of simple processes on a modern desktop PC

# The RMoX Operating System

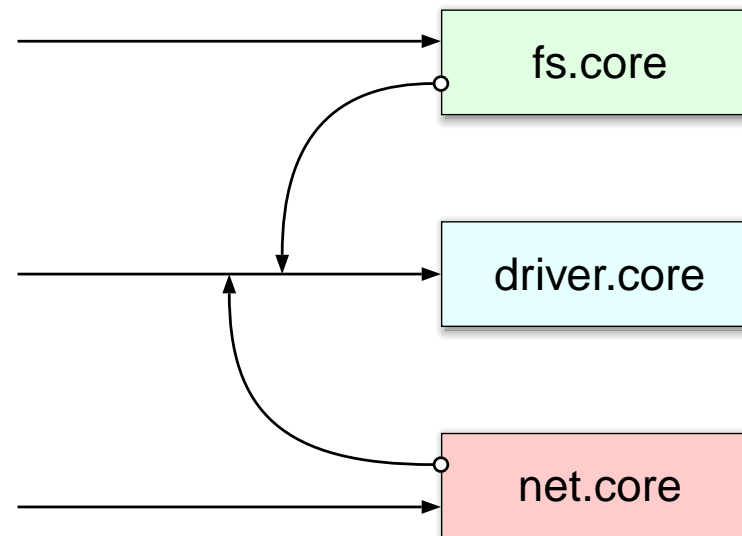
## The RMoX Operating System

- ▶ RMoX is an operating-system built using occam- $\pi$ , utilising concurrency at its lowest level — currently for Intel Pentium based hardware
- ▶ EPSRC funded project (EP/D061822/1) to develop RMoX for PC/104 systems
- ▶ Theory is: build an OS out of layered networks of communicating concurrent processes, and it will be:
  - **scalable**: from small embedded systems, through general-purpose (desktop) computers, up to massively parallel supercomputers
  - **reliable**: freedom from race-hazard and aliasing errors
  - **efficient**: low overheads (sub 100ns context-switch), no need for heavyweight memory-management (maybe)

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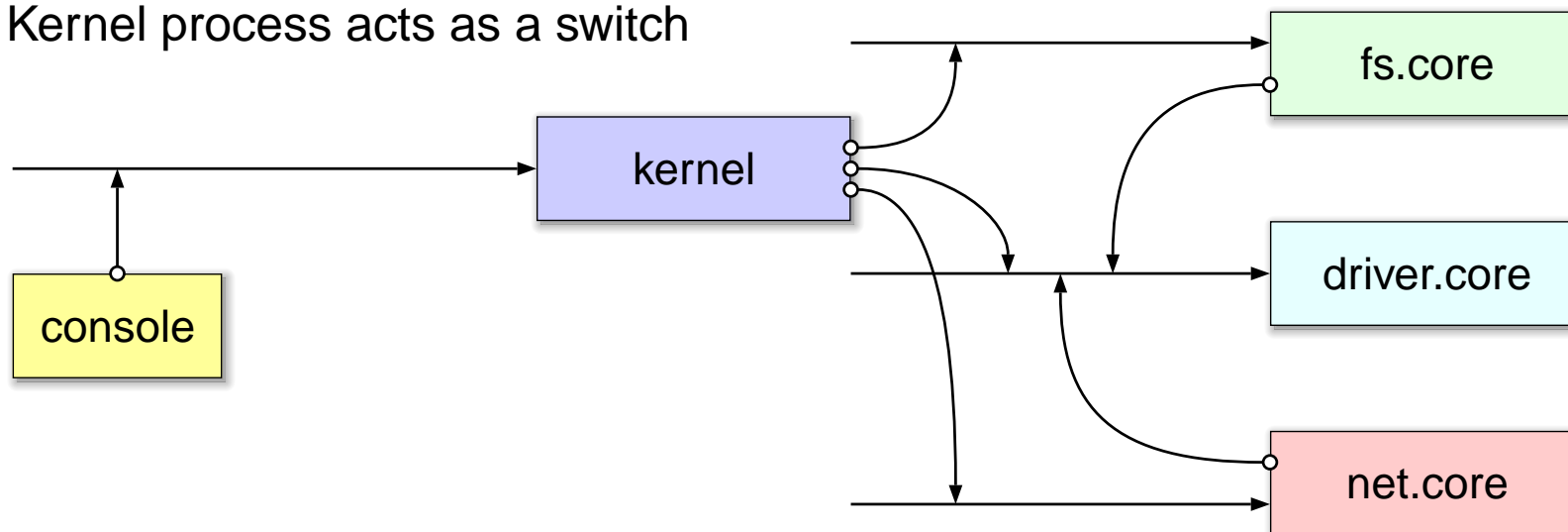
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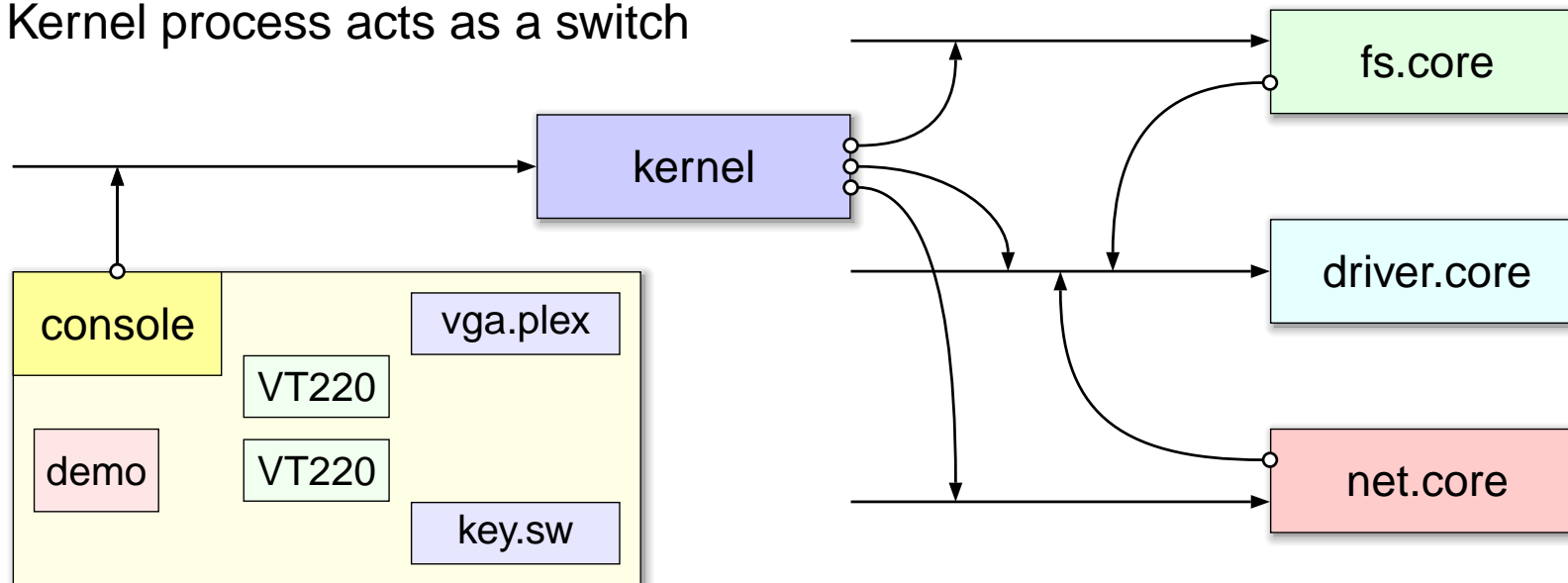
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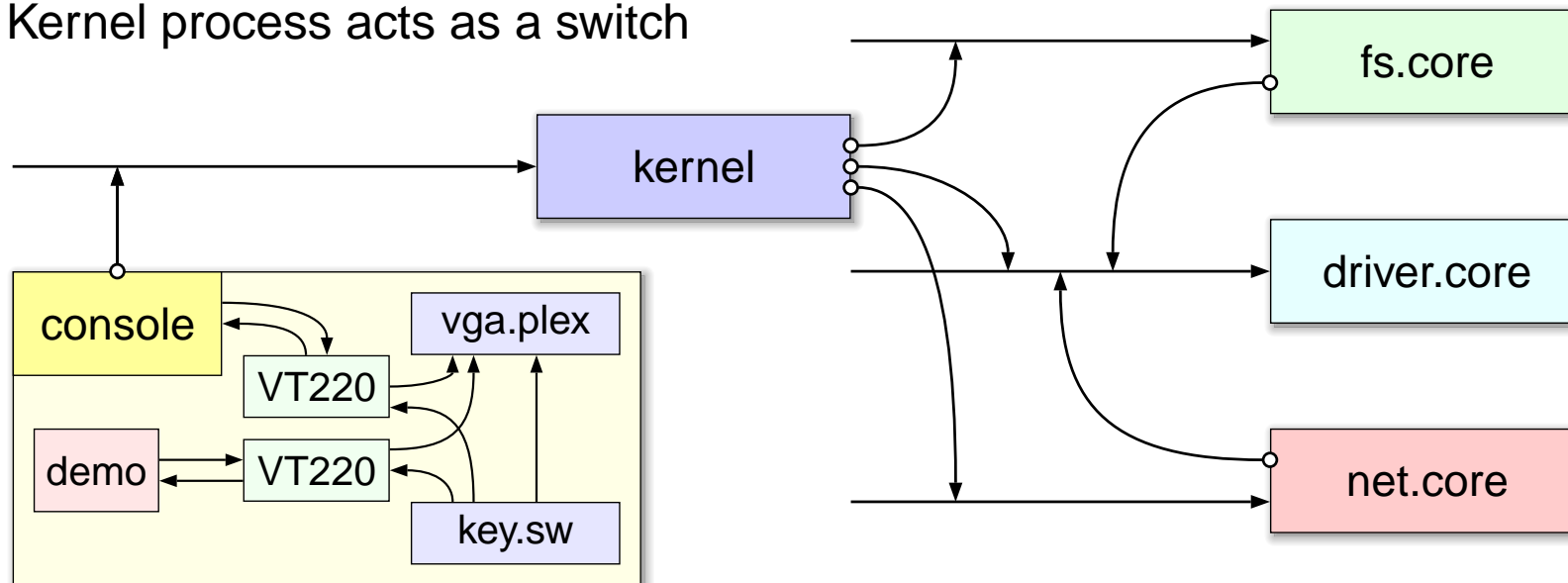
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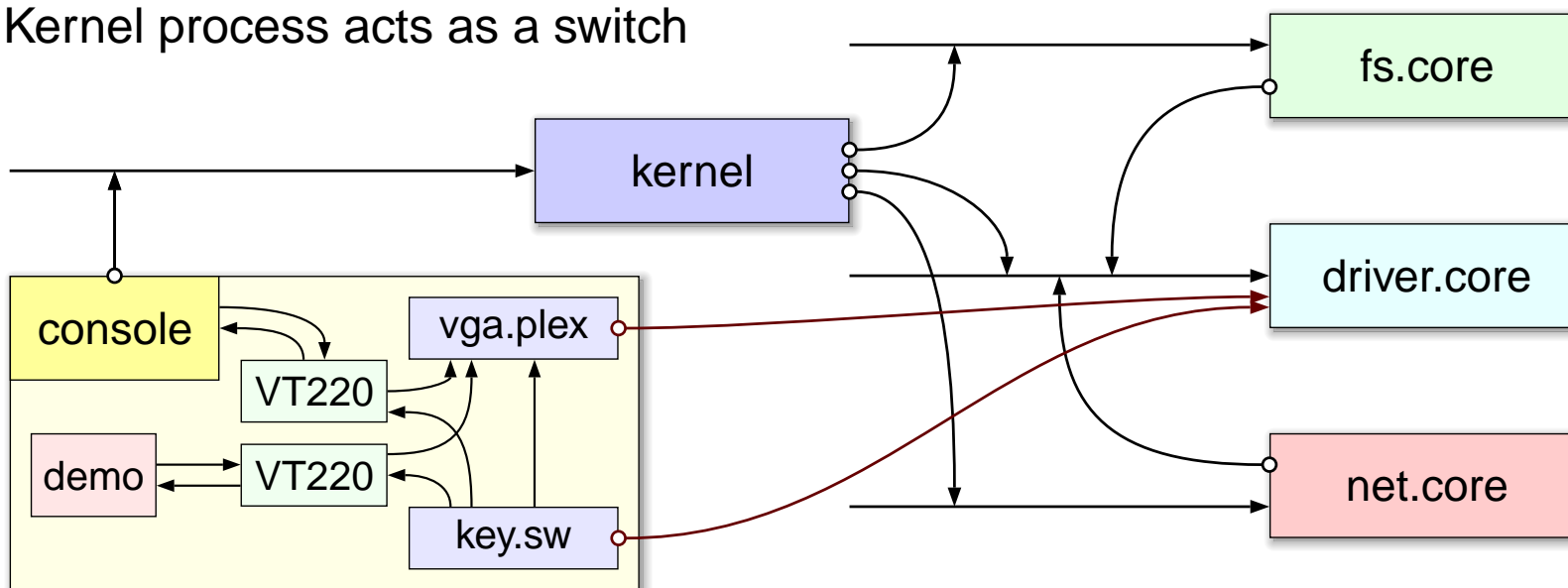
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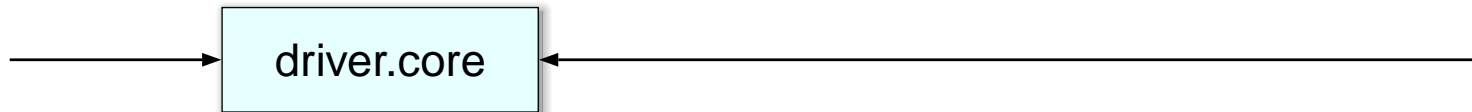


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- Connections within dynamically formed and dismantled as required

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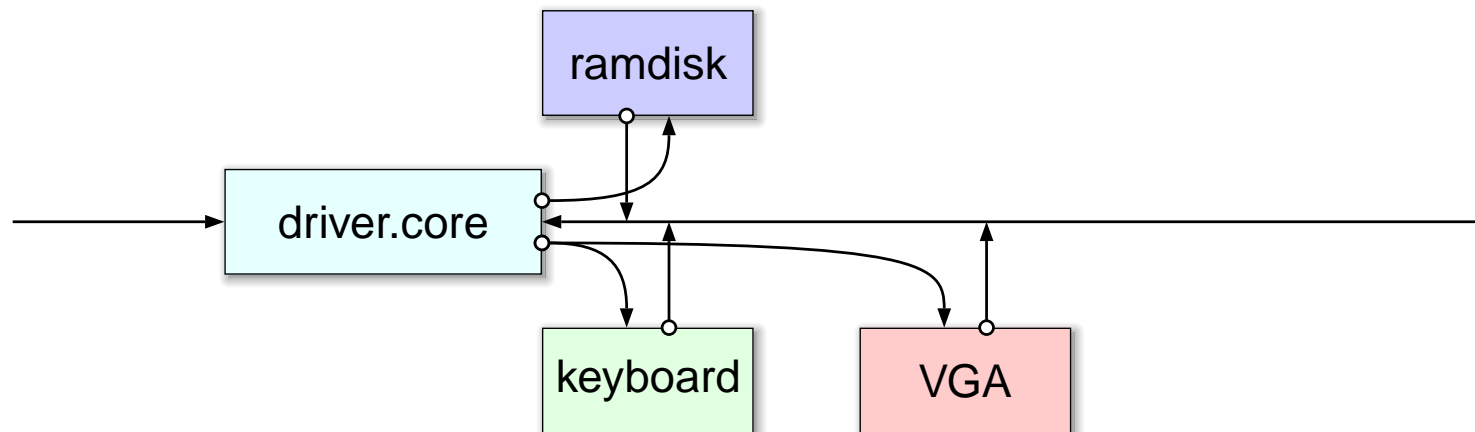
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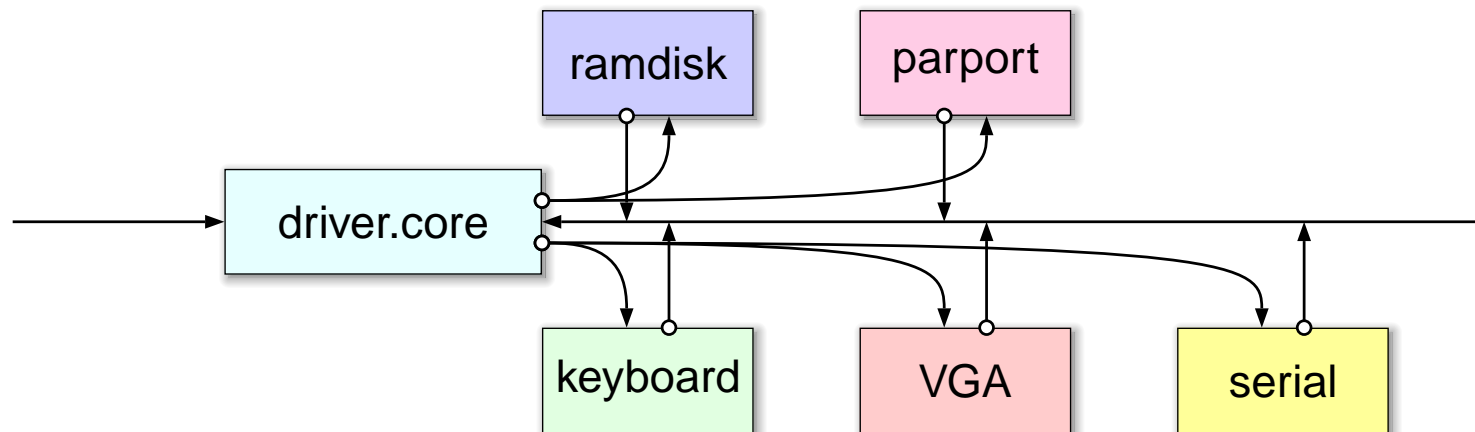
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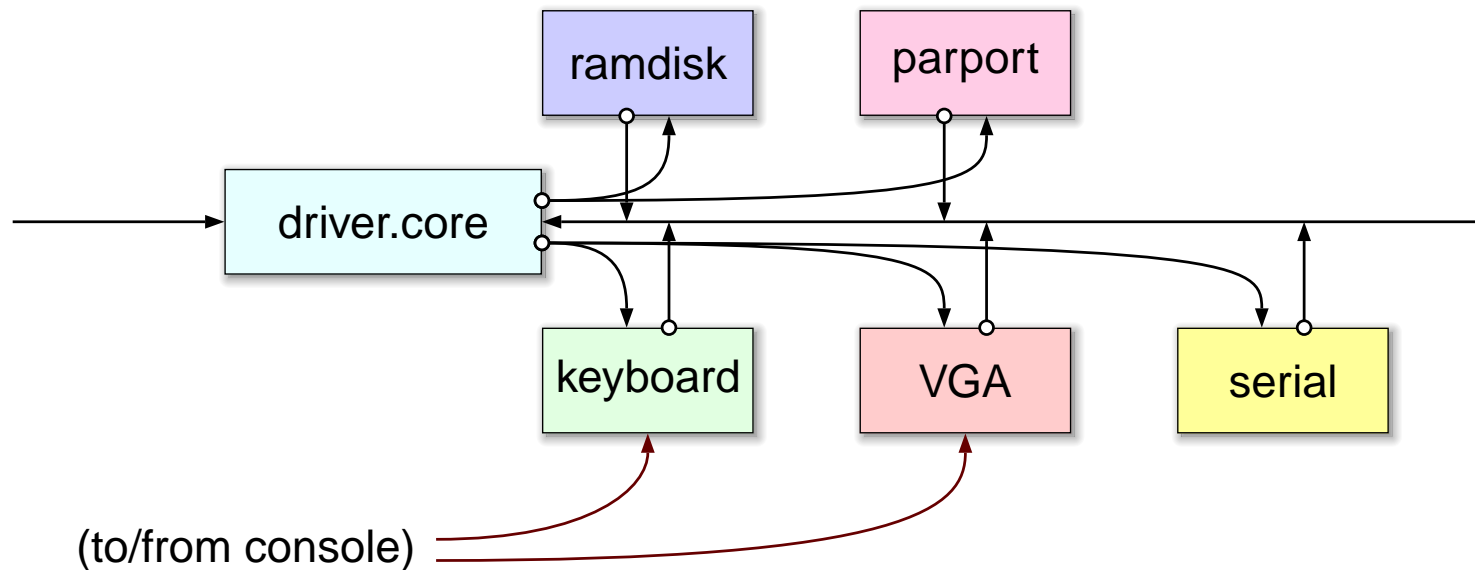
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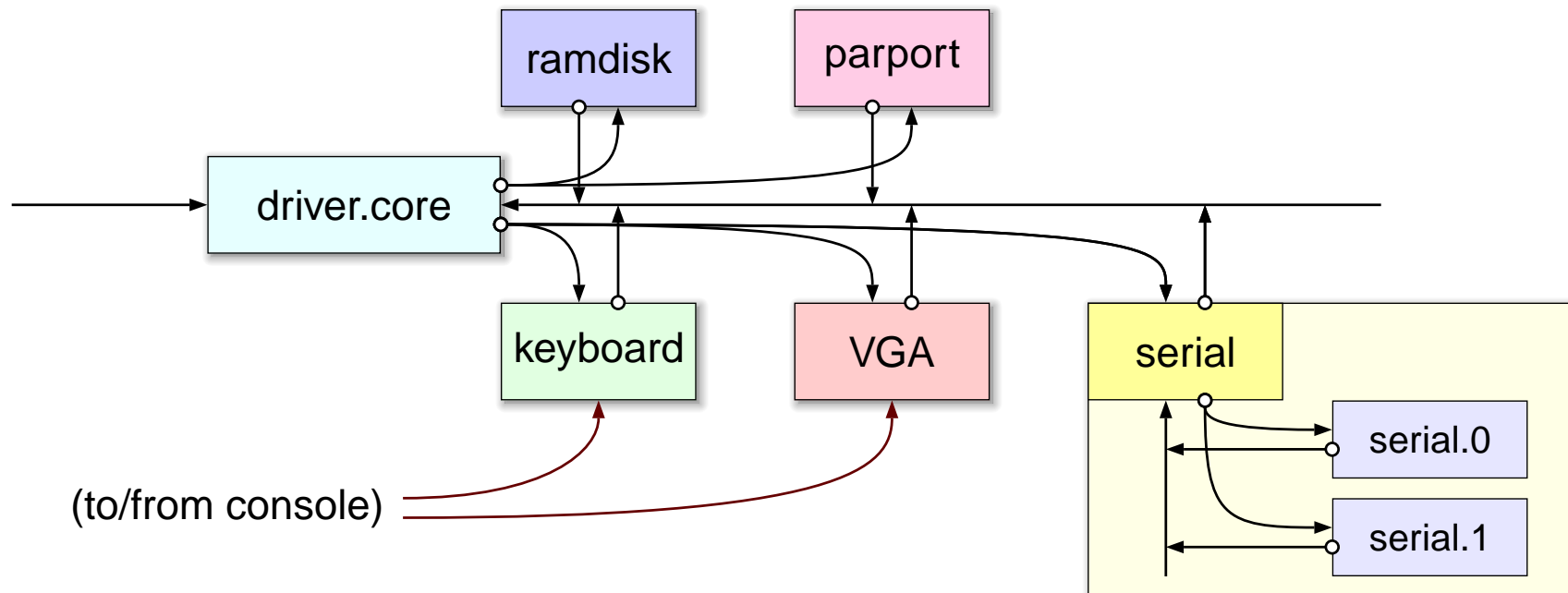
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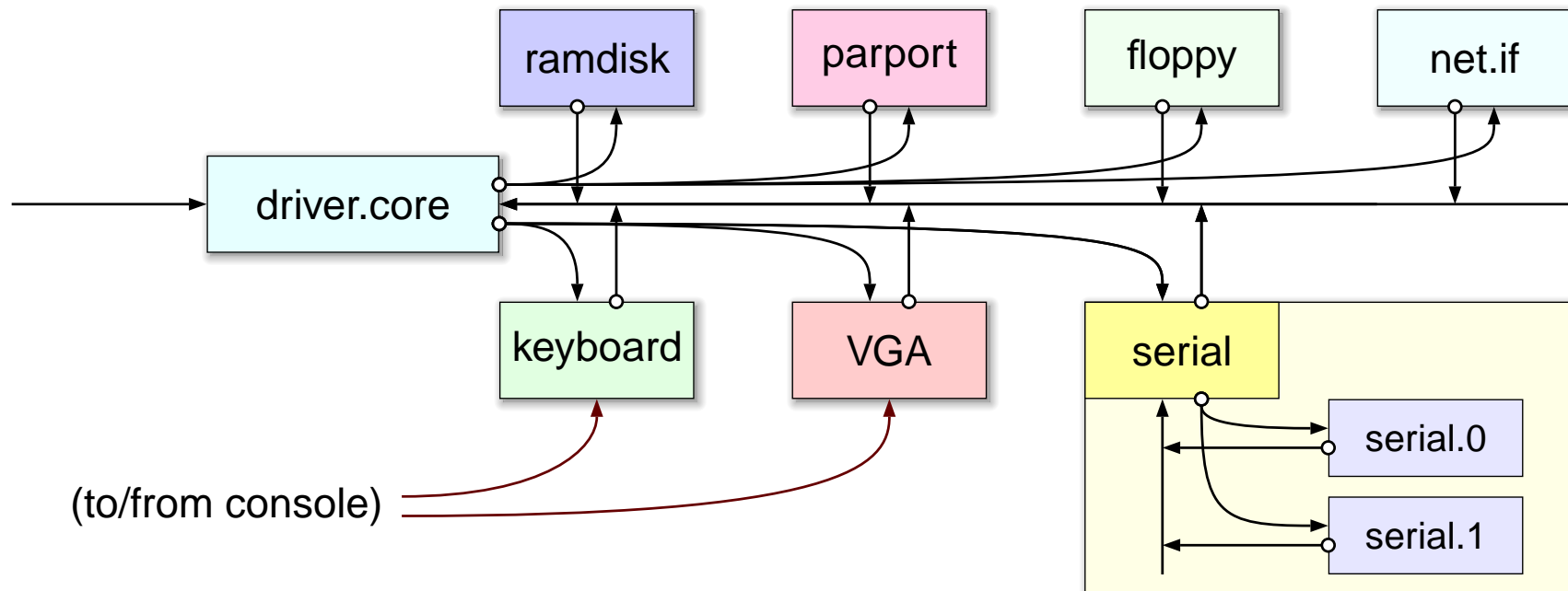
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- Drivers themselves may be concurrent internally
- Some drivers mostly complete, others under construction

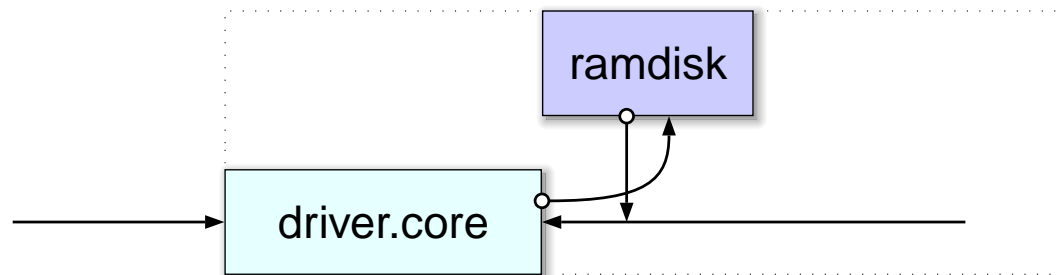
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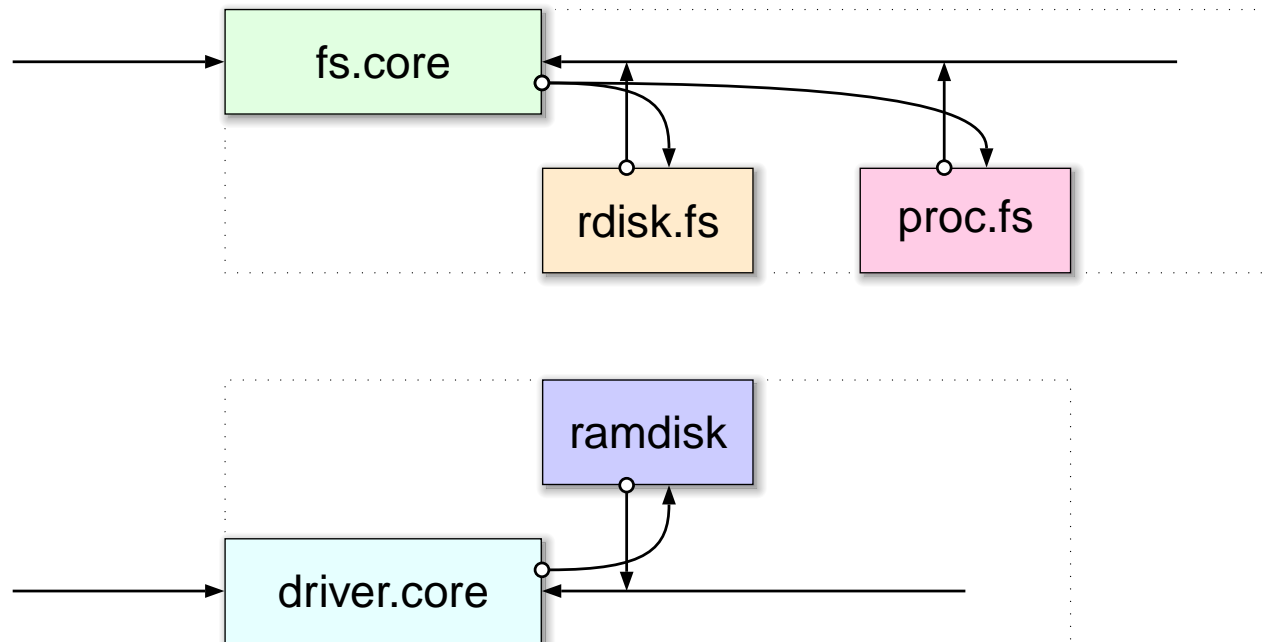
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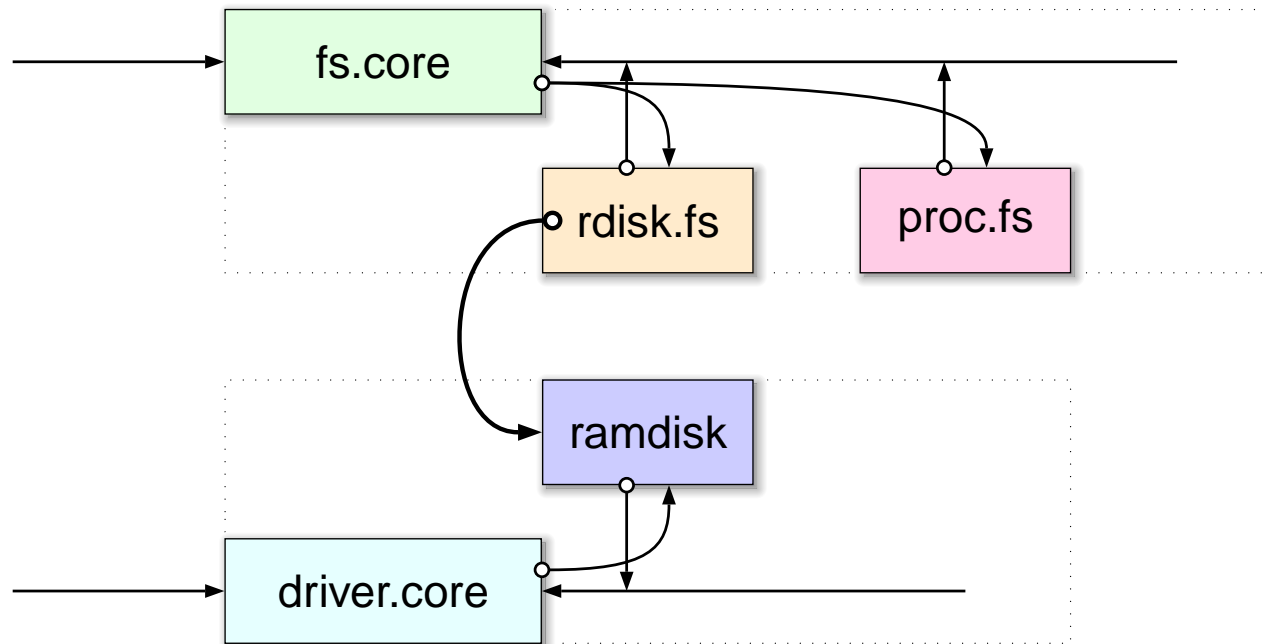
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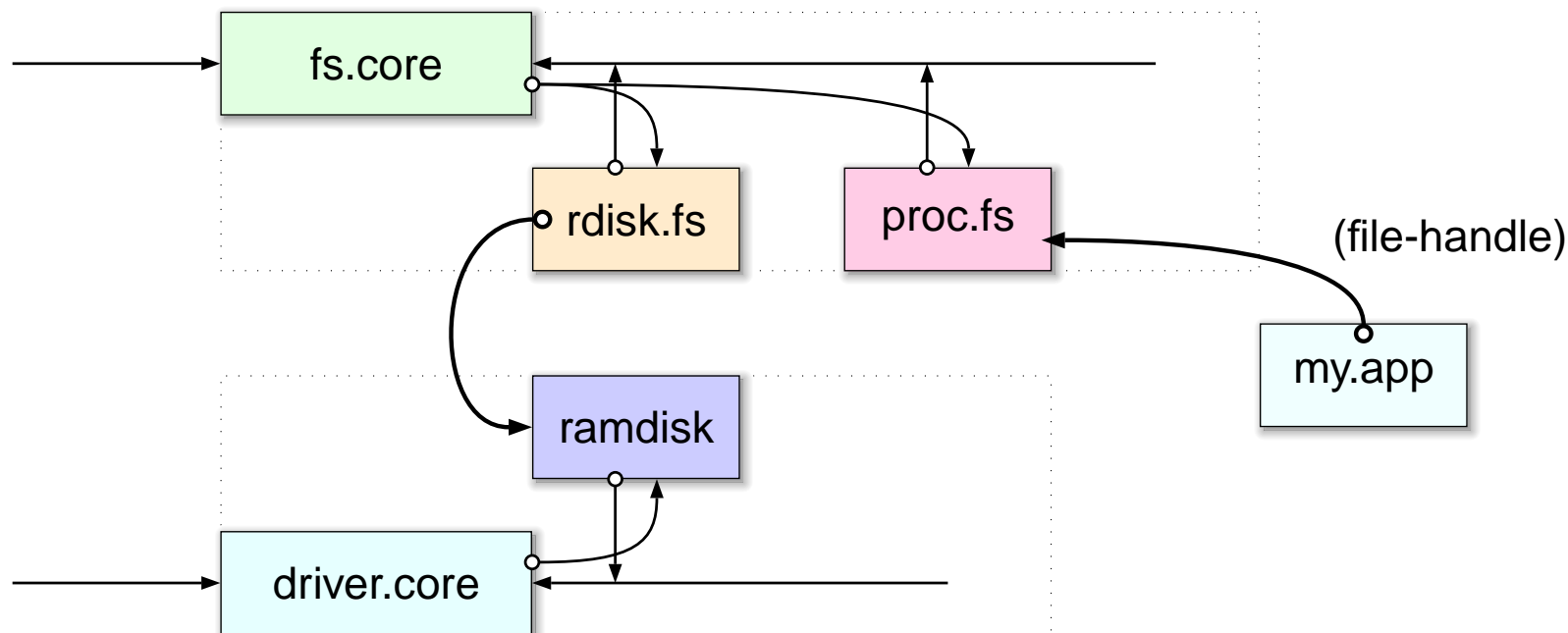
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- Process networks for things such as PCI and USB drivers reflect hardware organisation — not a complex mass of sequential code!

# USB Hardware

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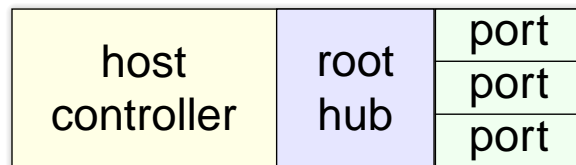
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  - bus is strictly controlled: single **host controller** polls devices and offers bandwidth for transfers — UHCI, EHCI and OHCI standards say how

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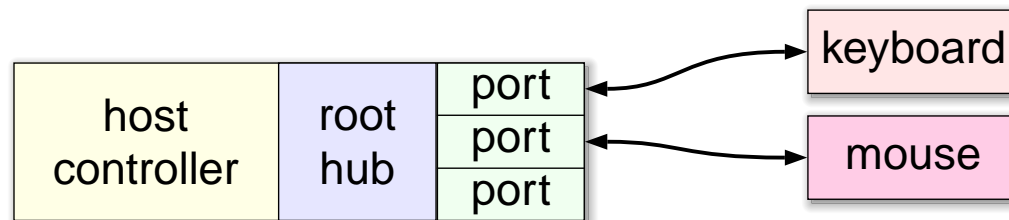
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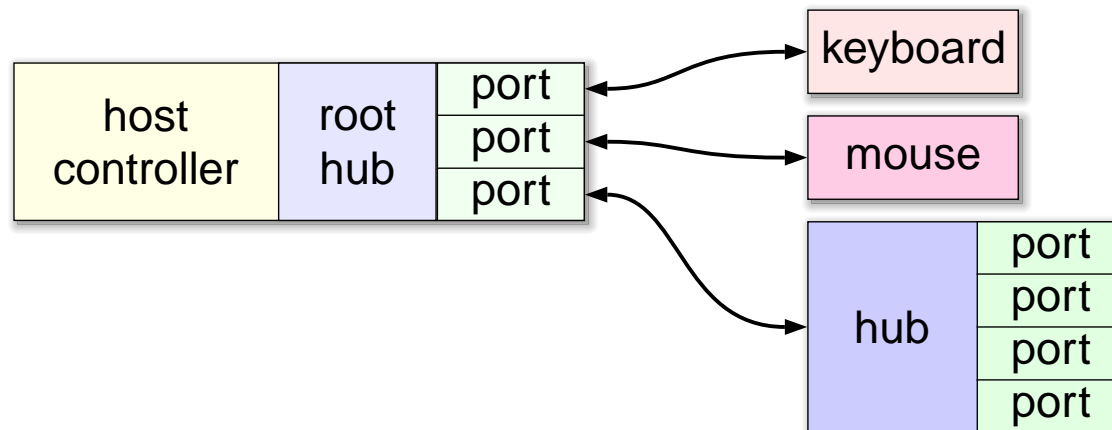
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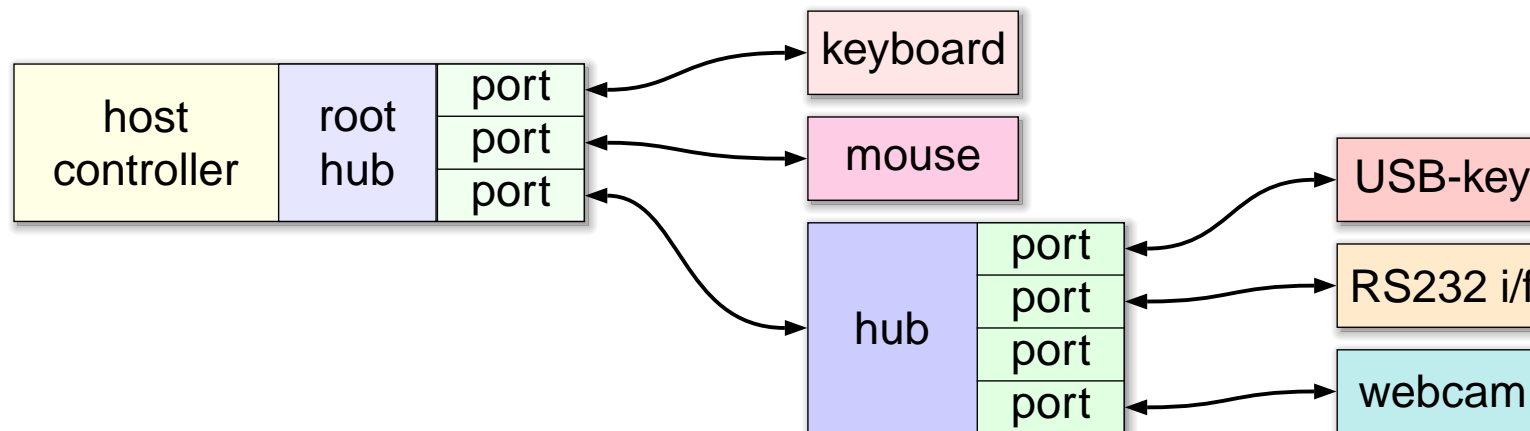
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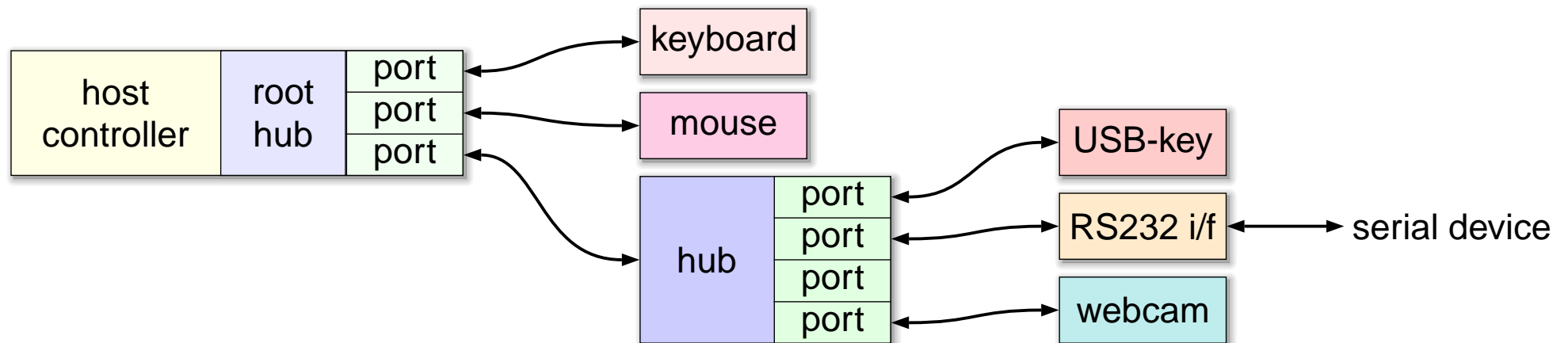
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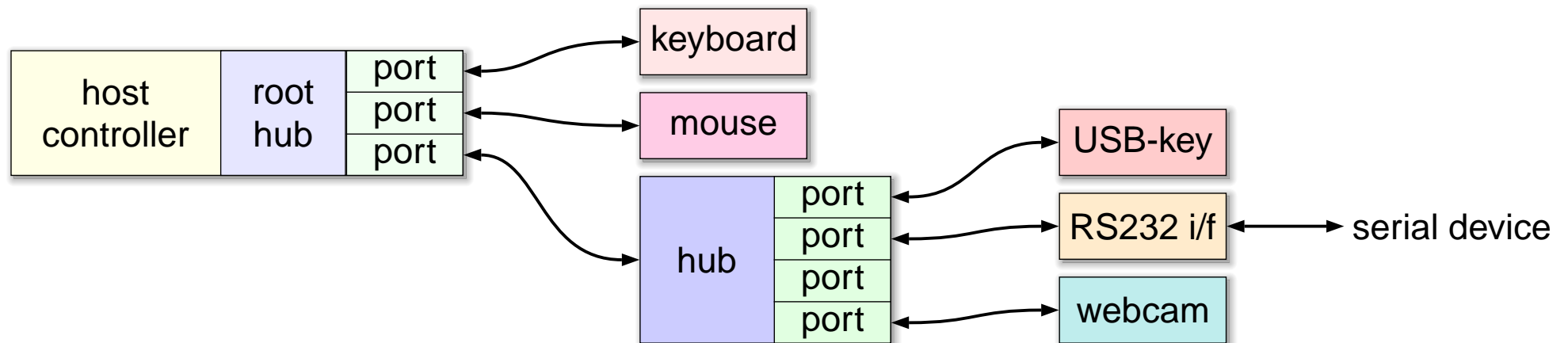
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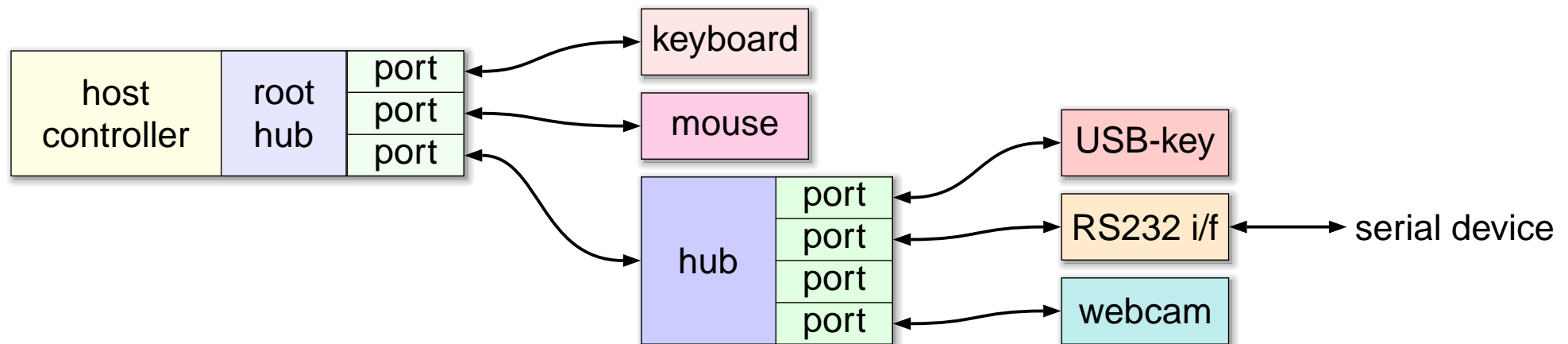


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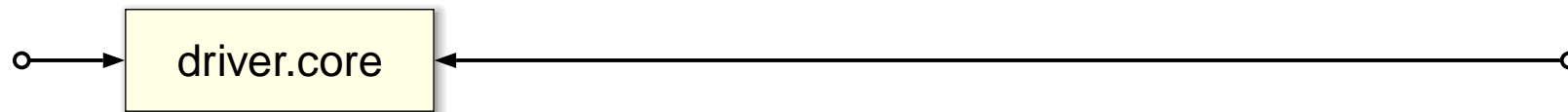


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- ▶ Range of devices is complex: simple peripherals, legacy interfaces, networking, ...

## Process Oriented USB

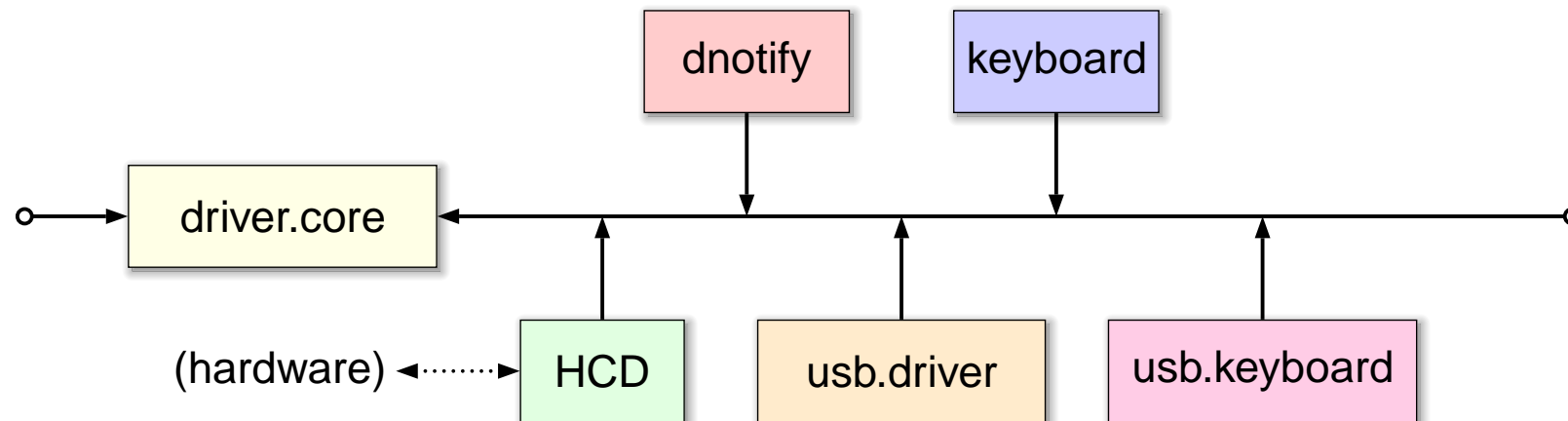
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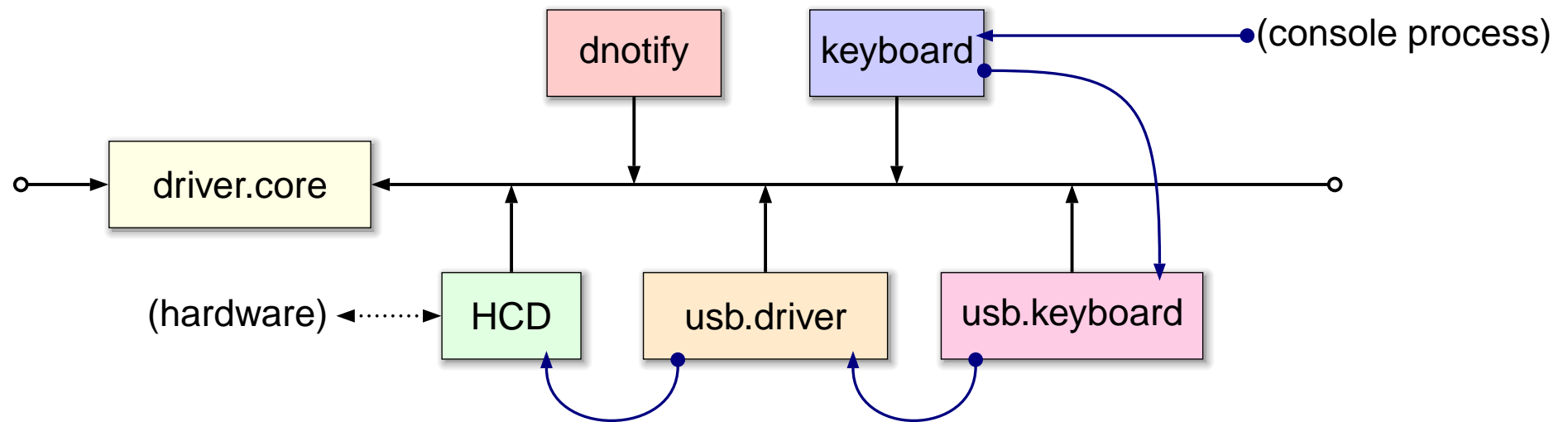
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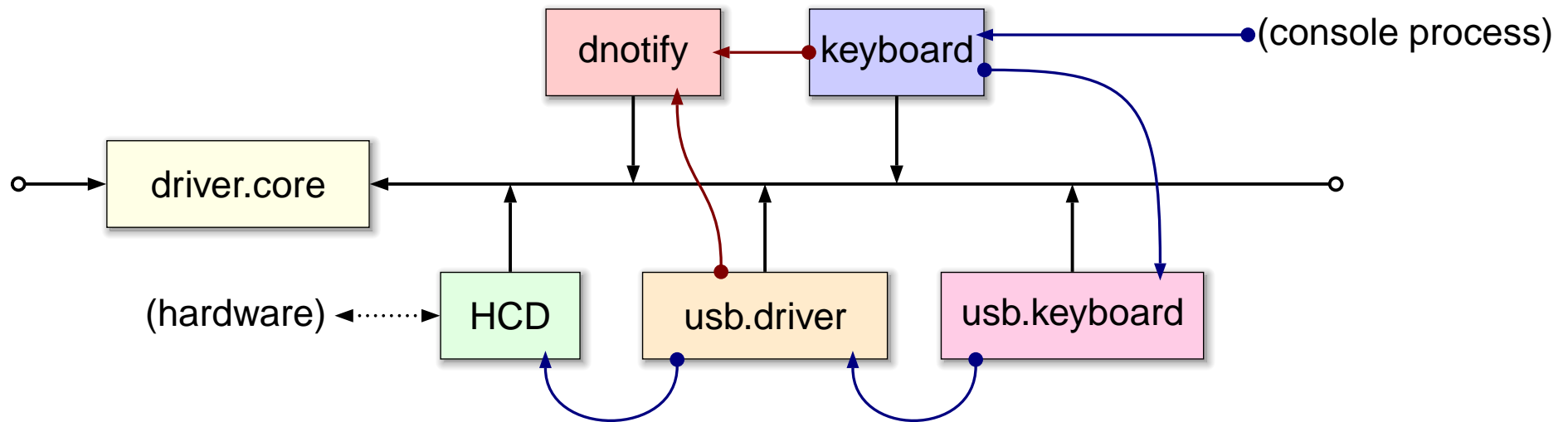
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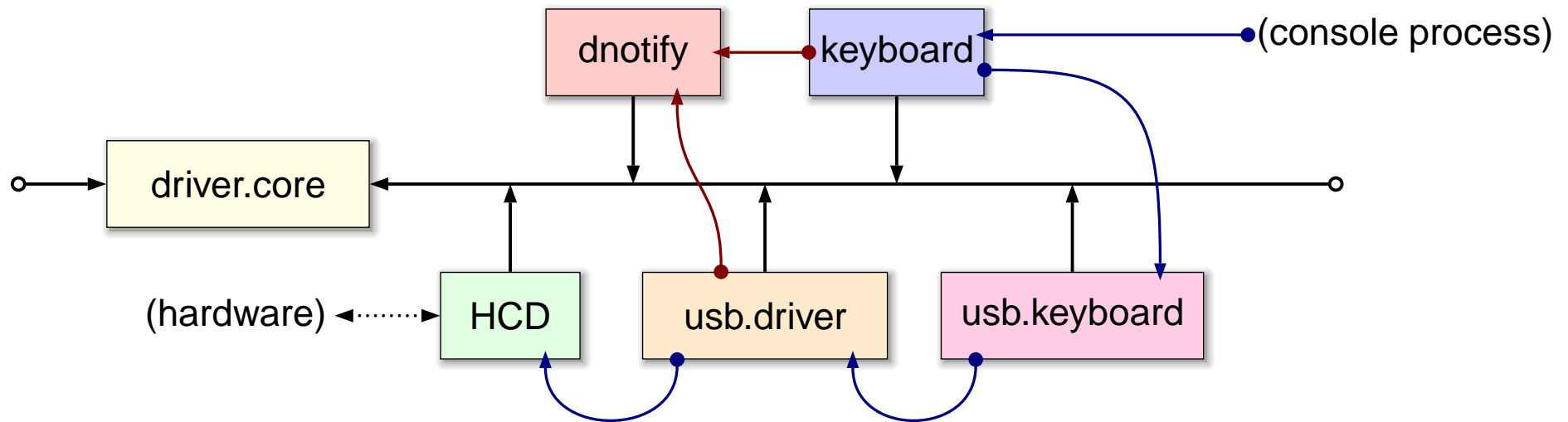
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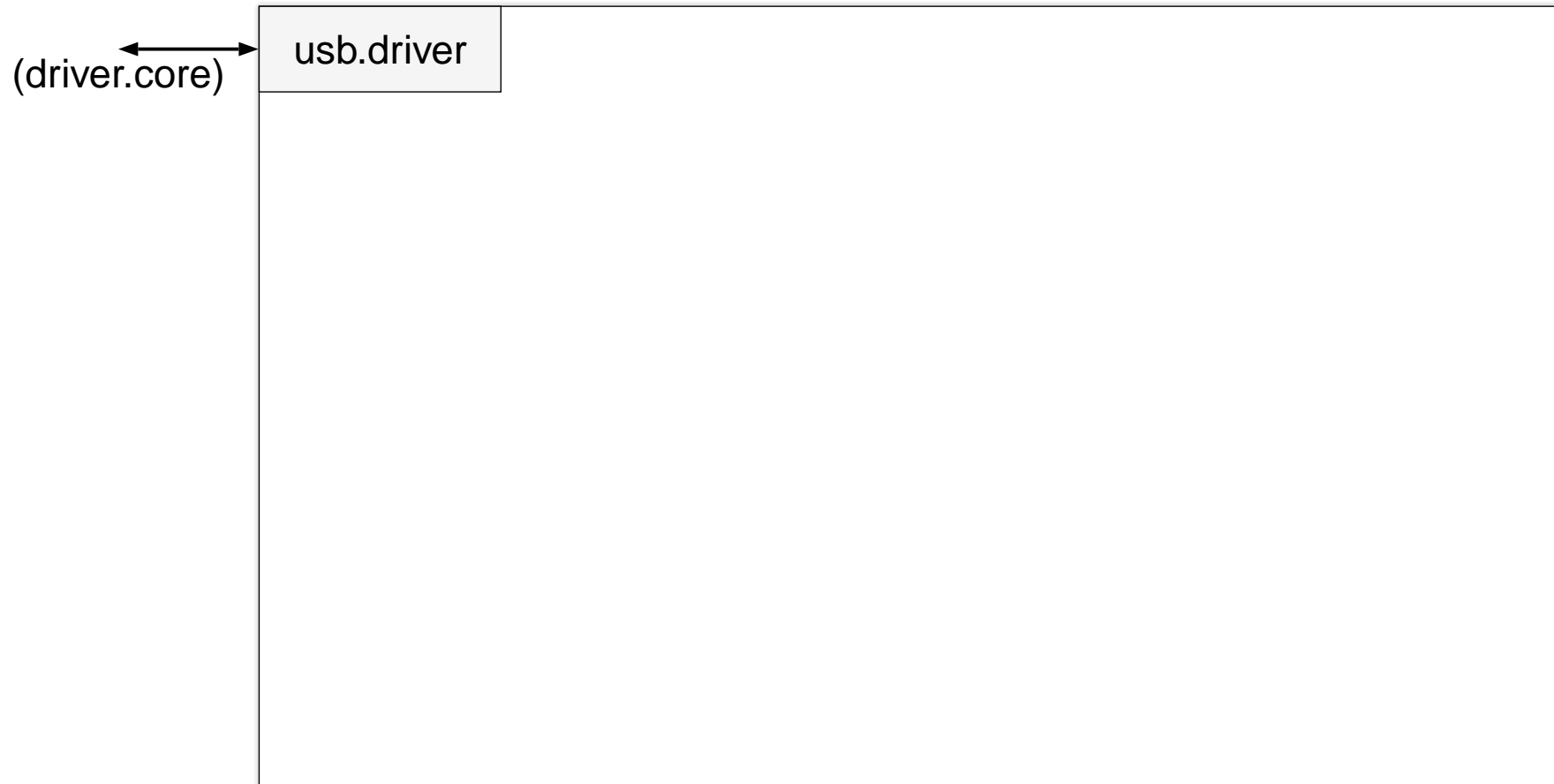
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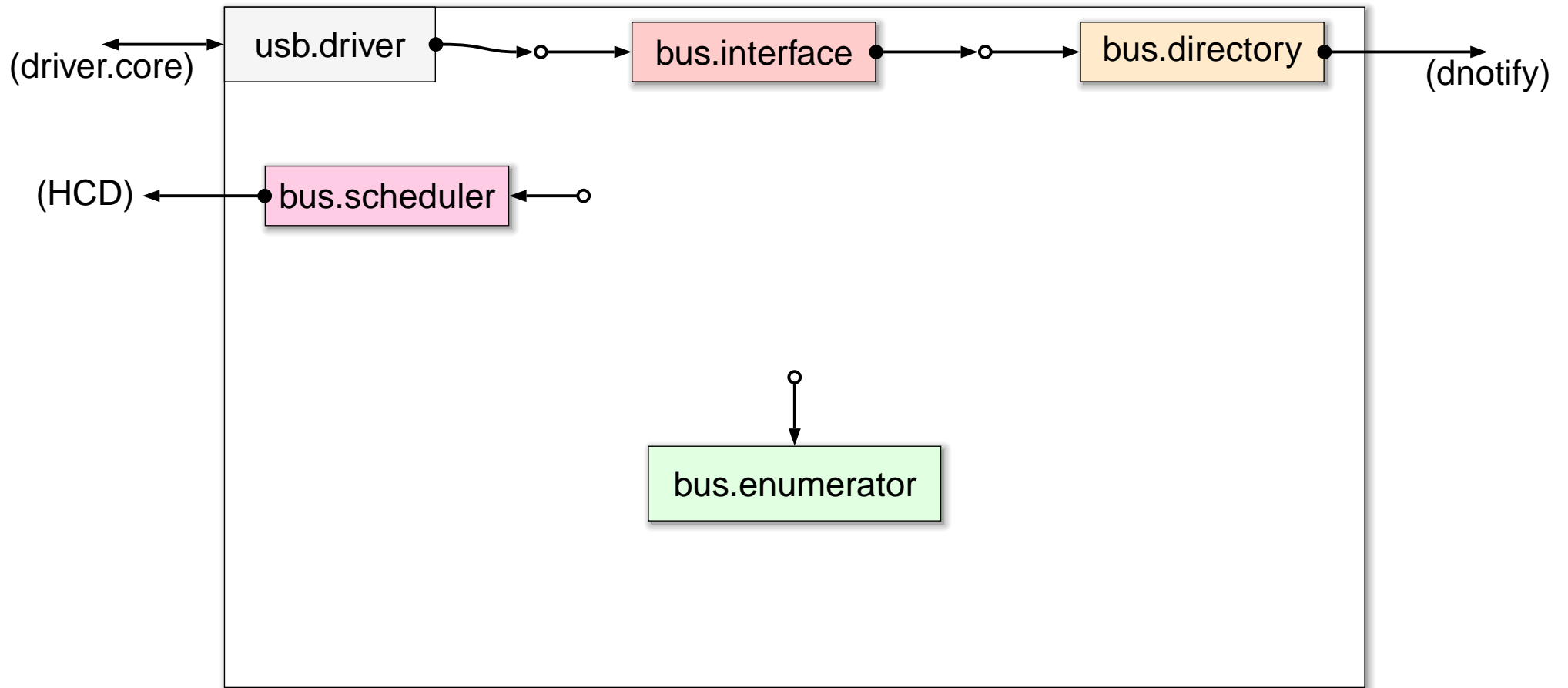
- **Device-notify** driver acts as a registration point, indicating when new USB devices are connected — routes connections between relevant device
- The **usb.driver** acts as a coordinator, with processes representing the physical structure — created and destroyed dynamically

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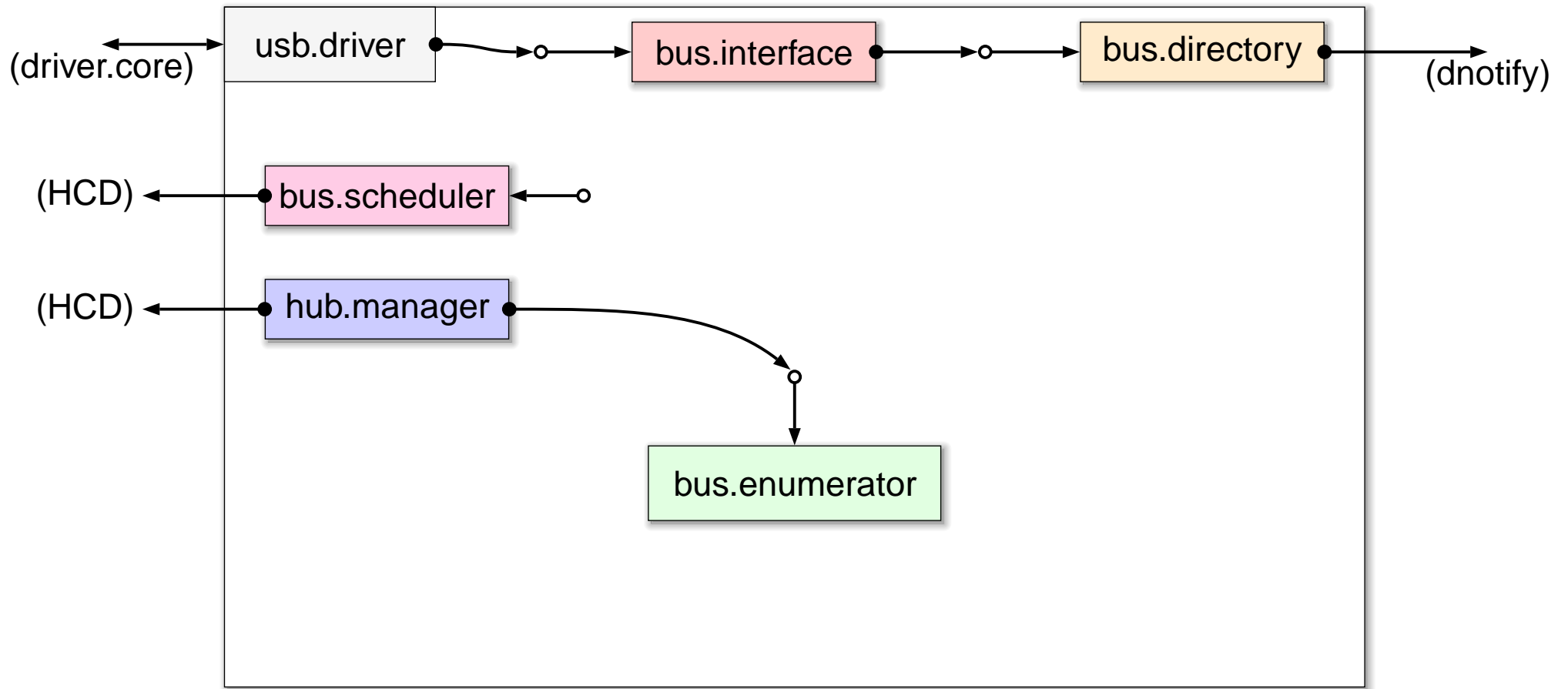
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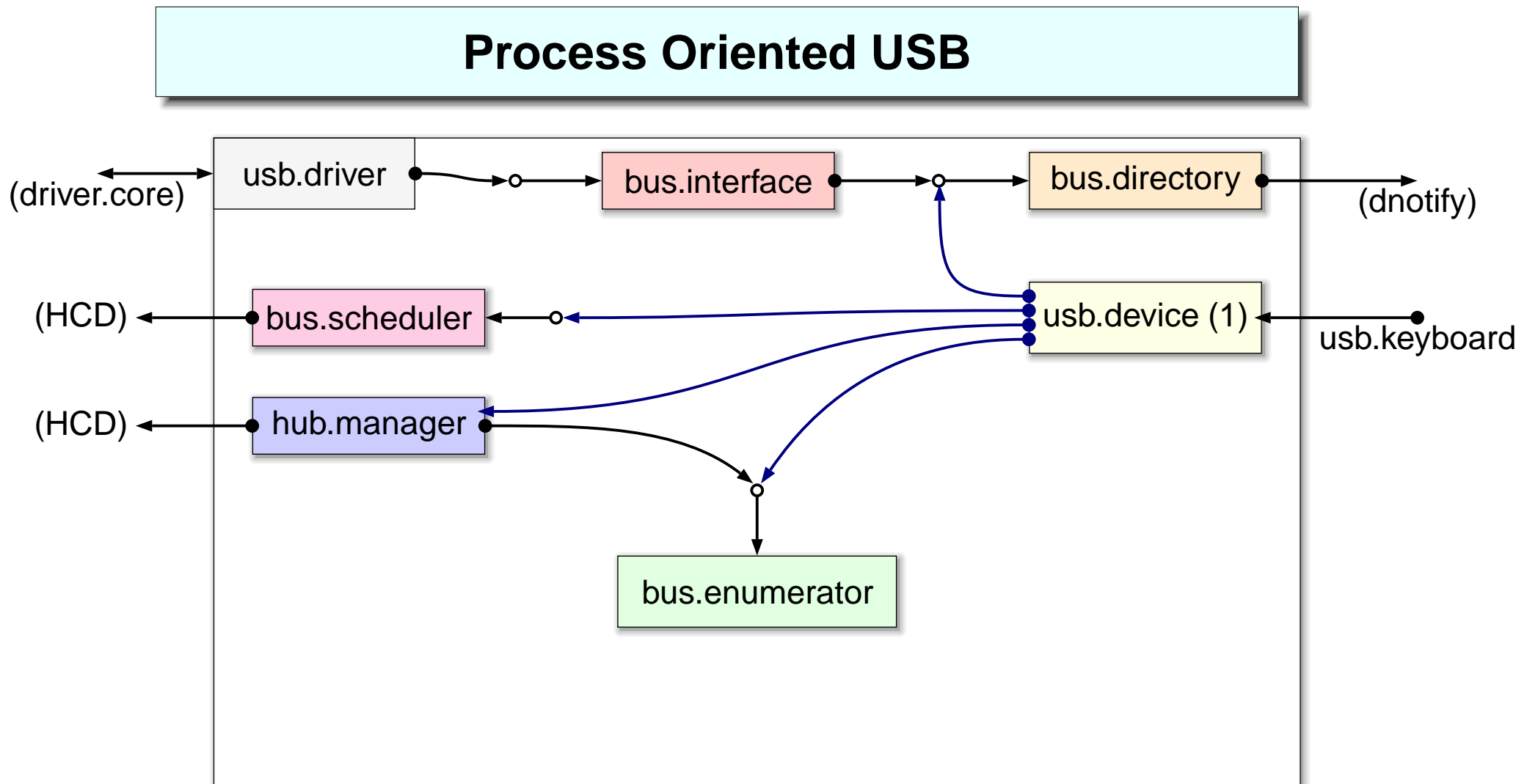


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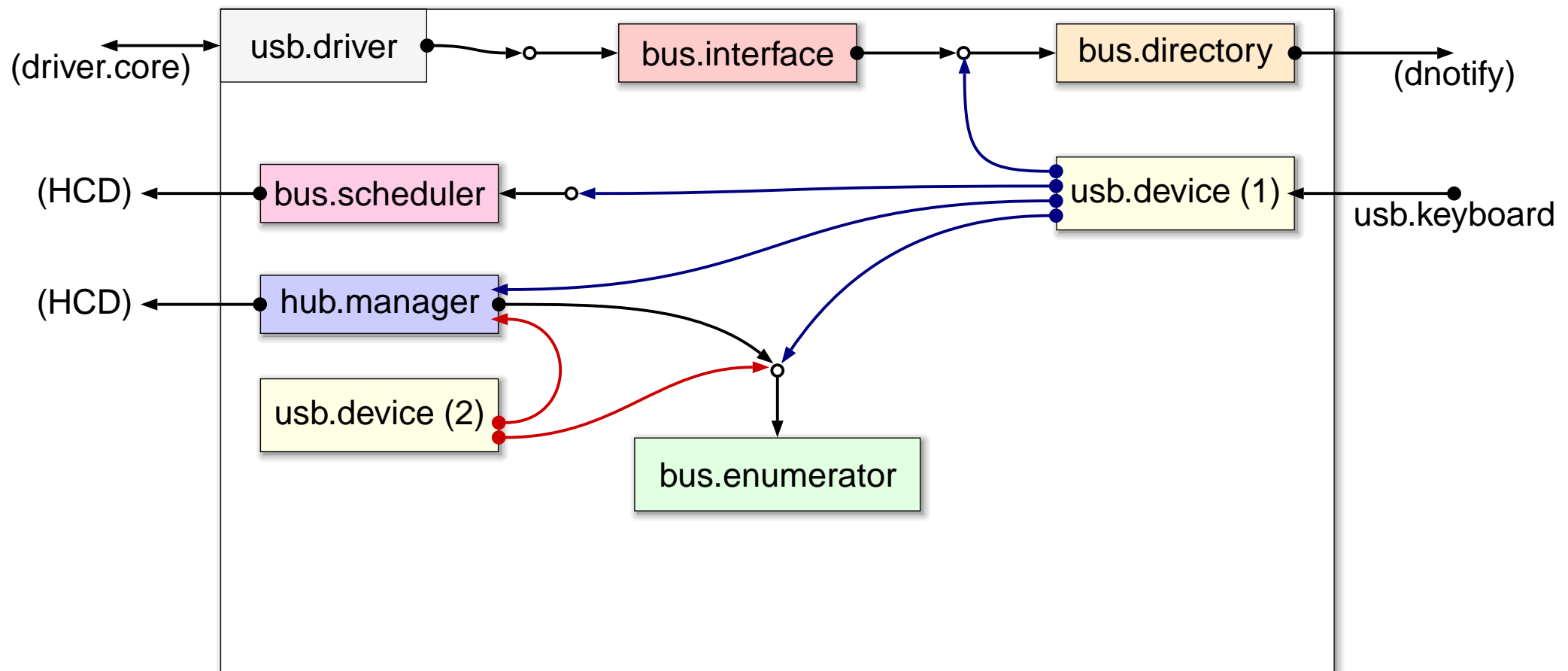
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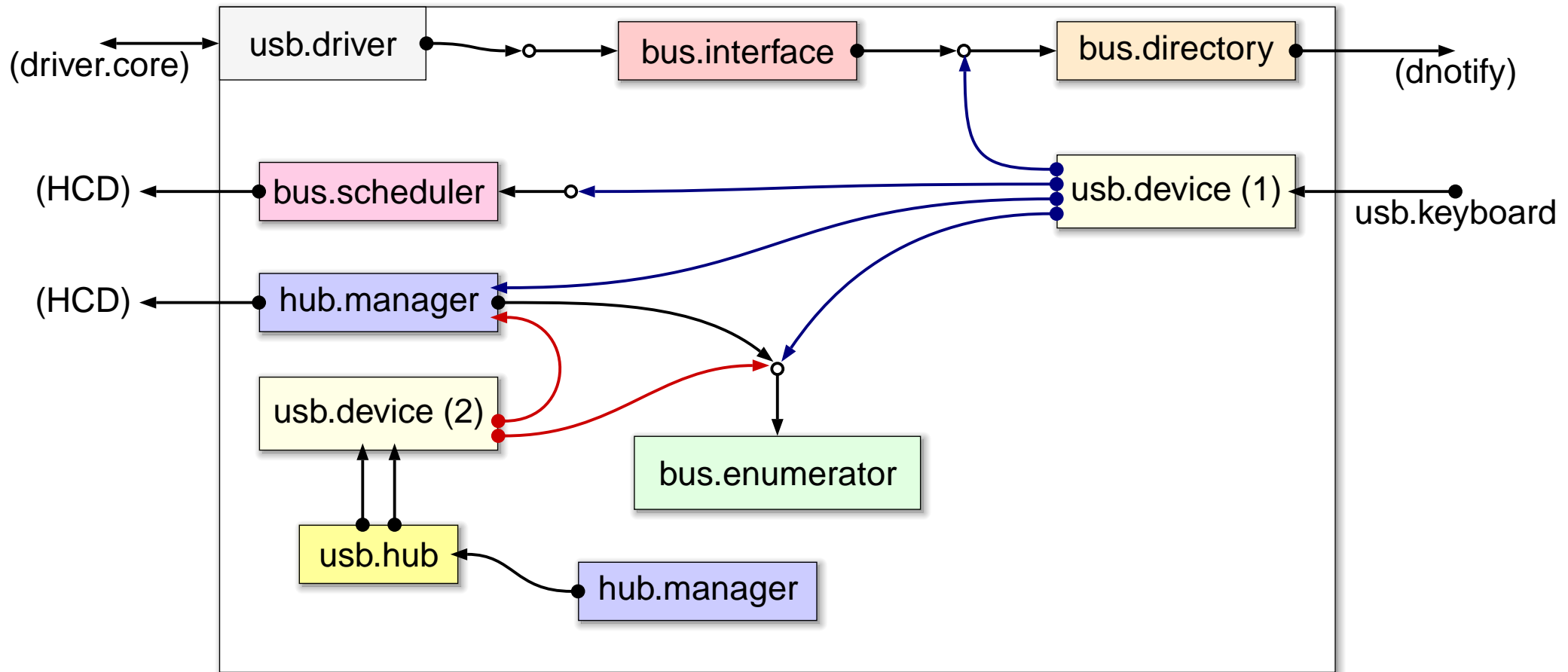
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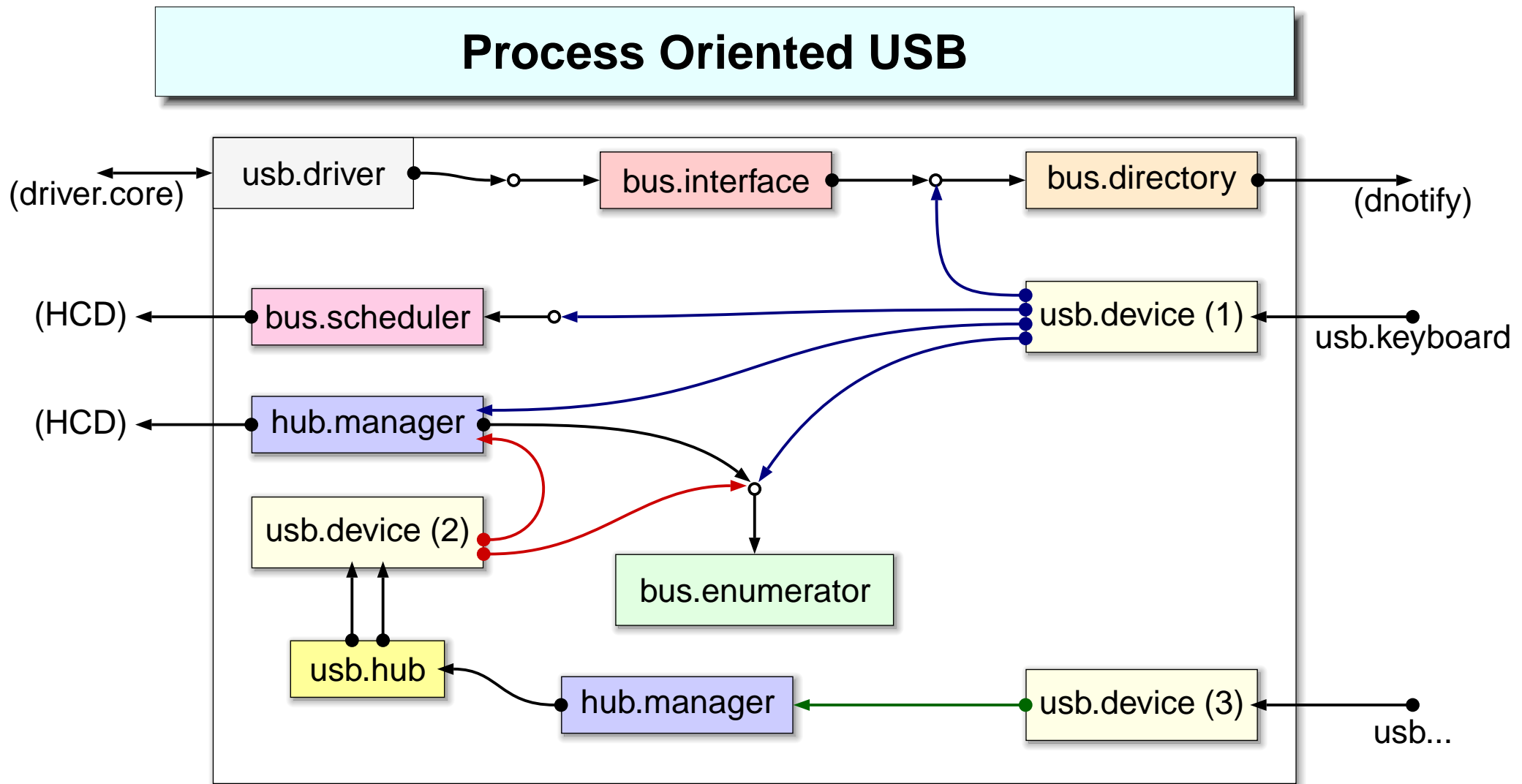


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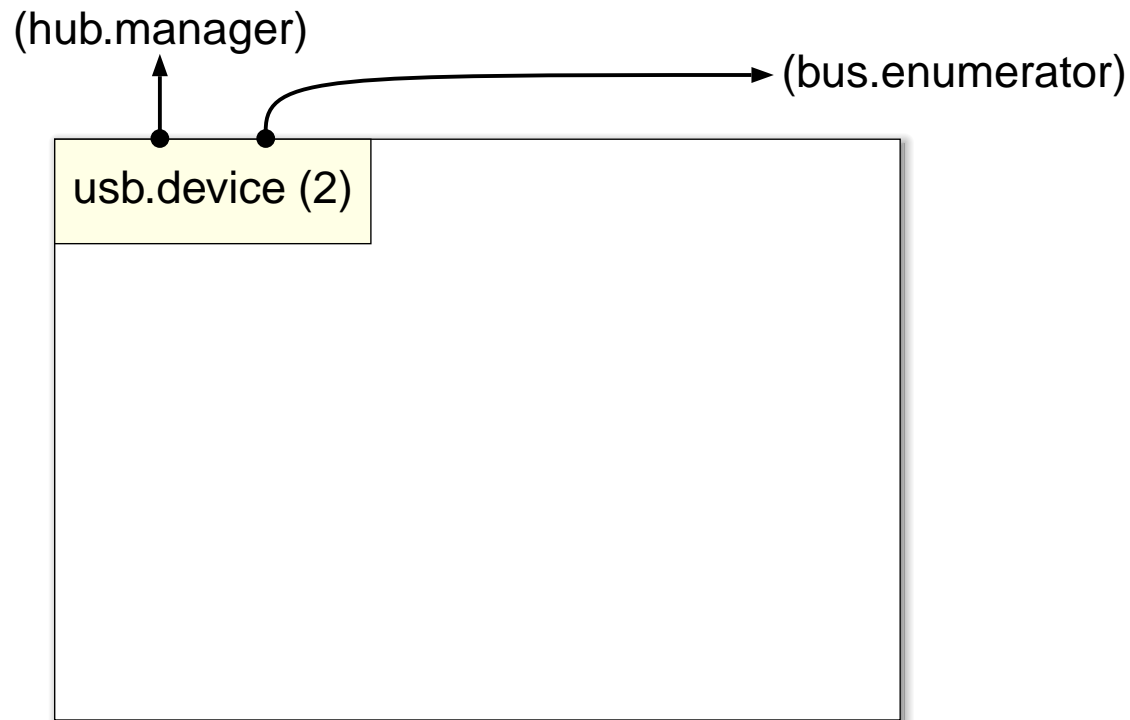
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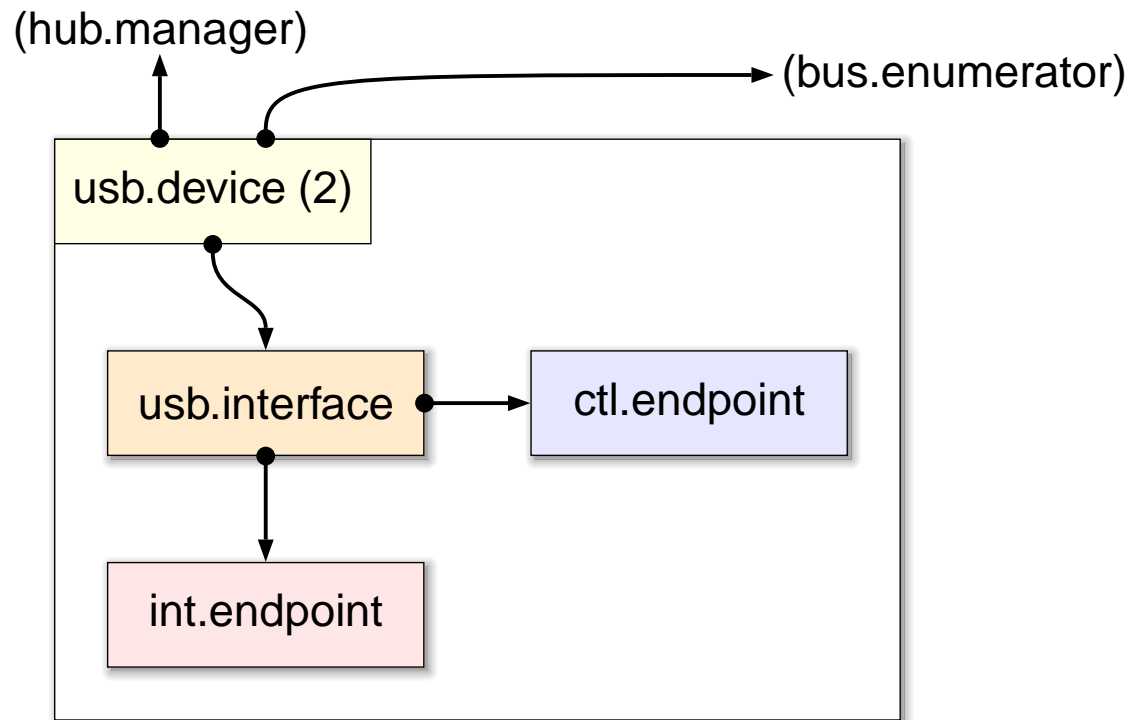
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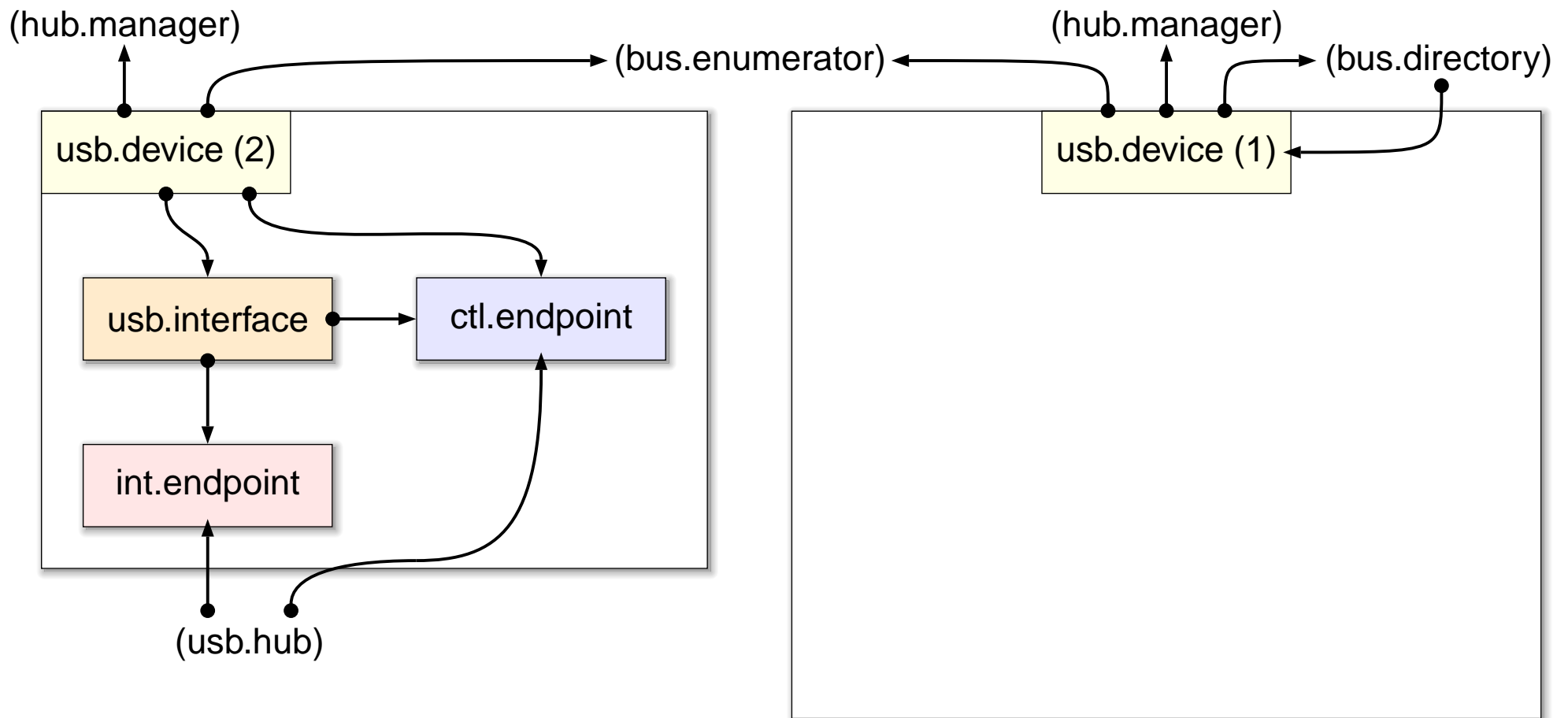
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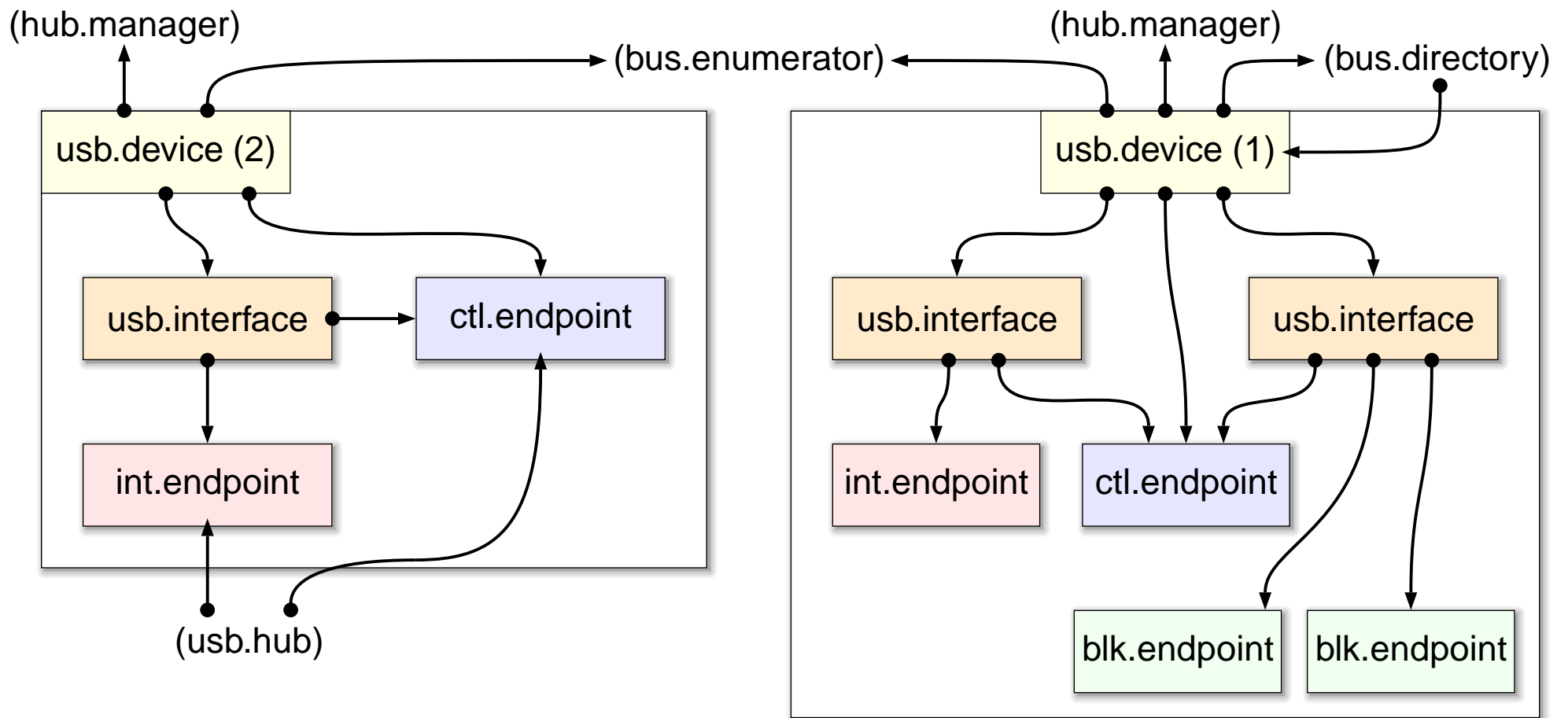
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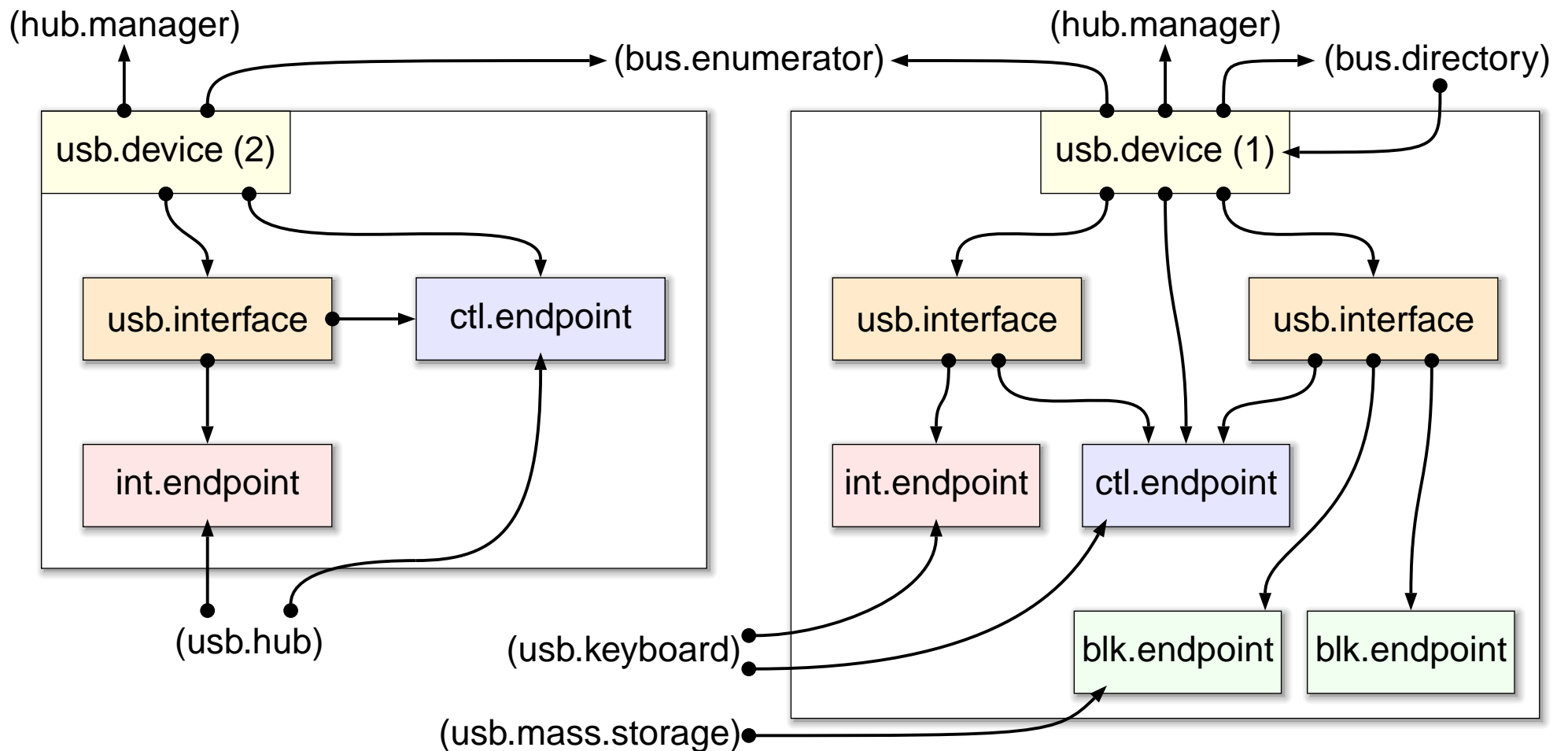
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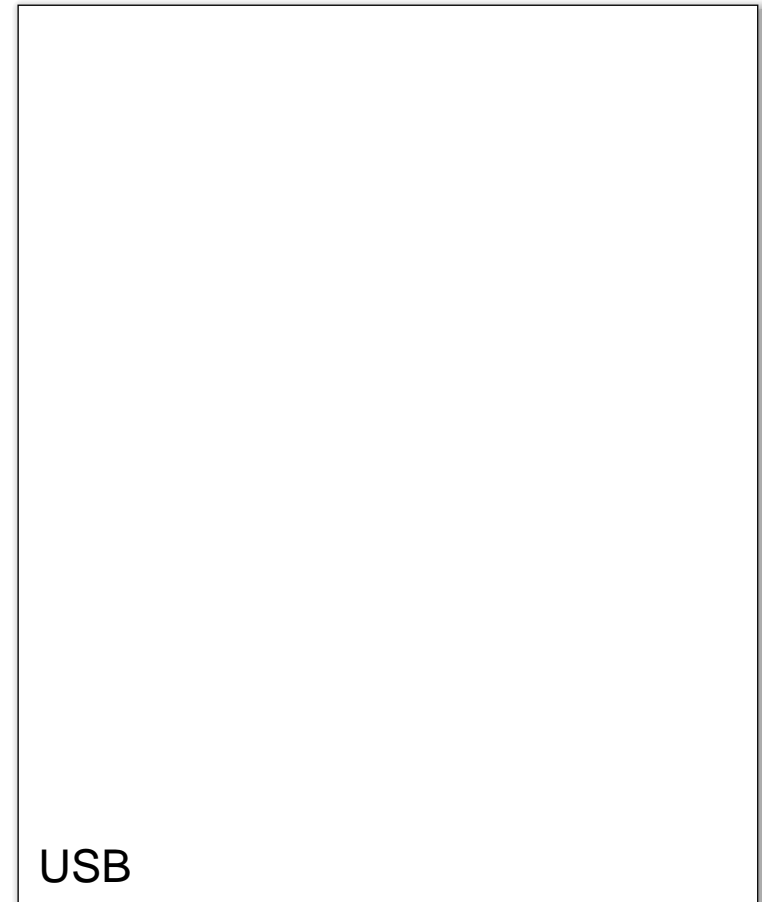
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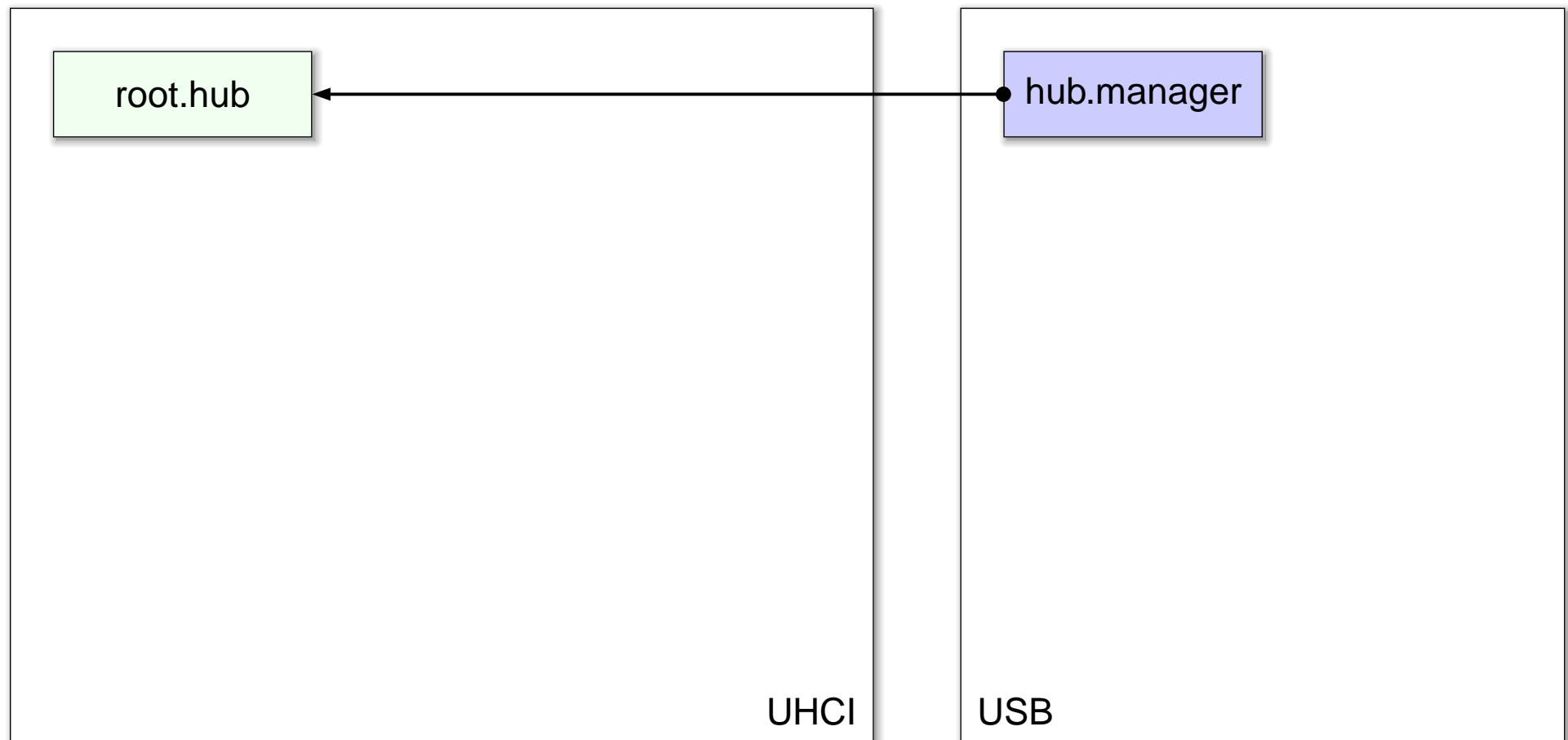
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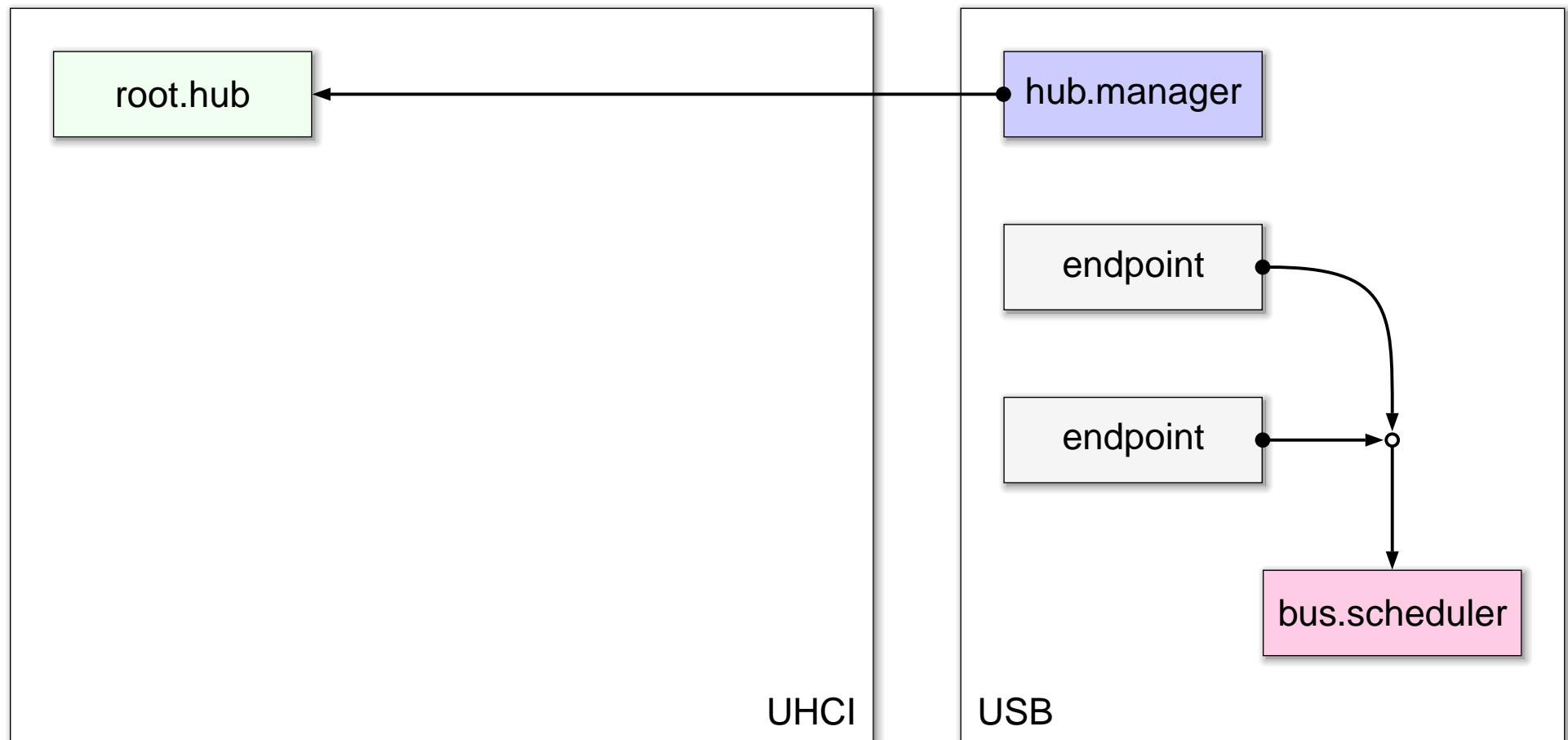
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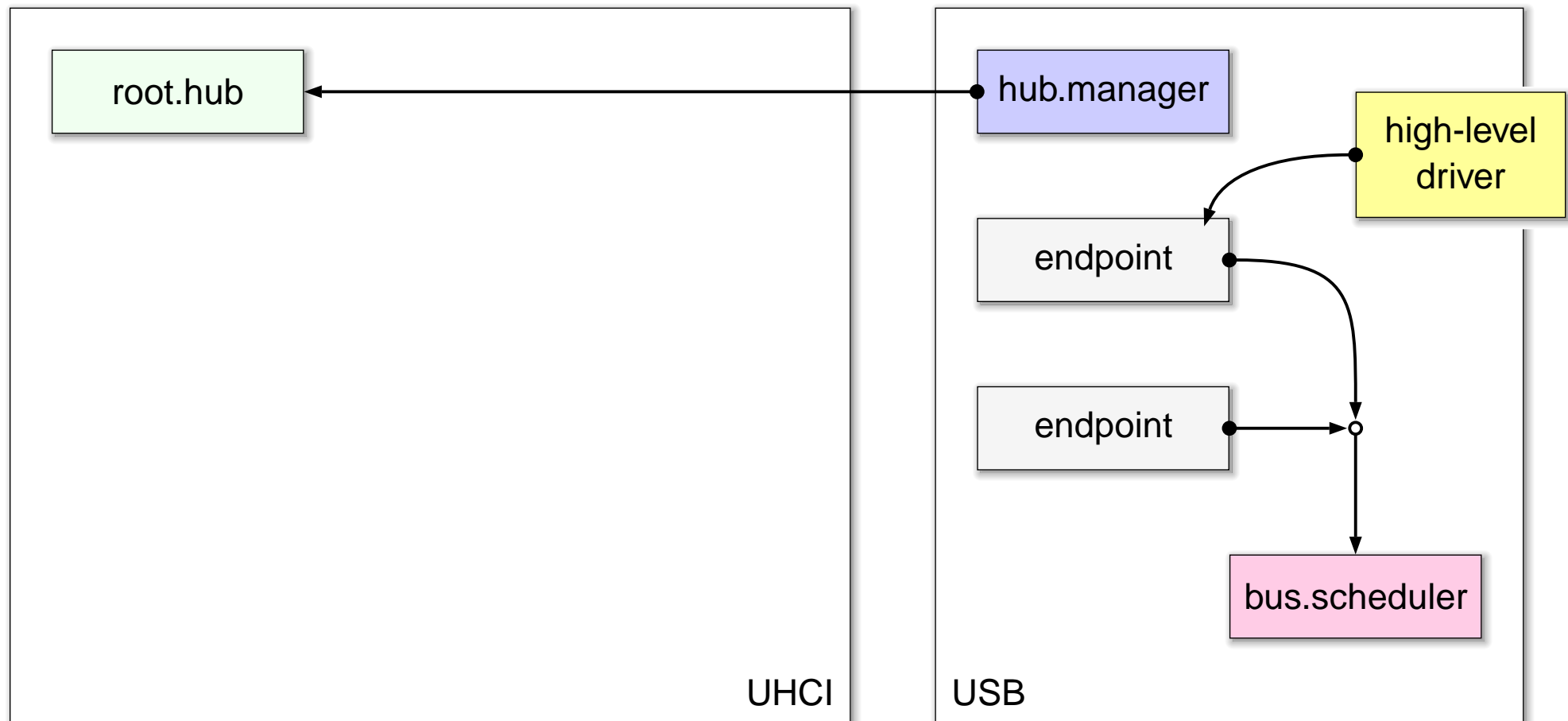
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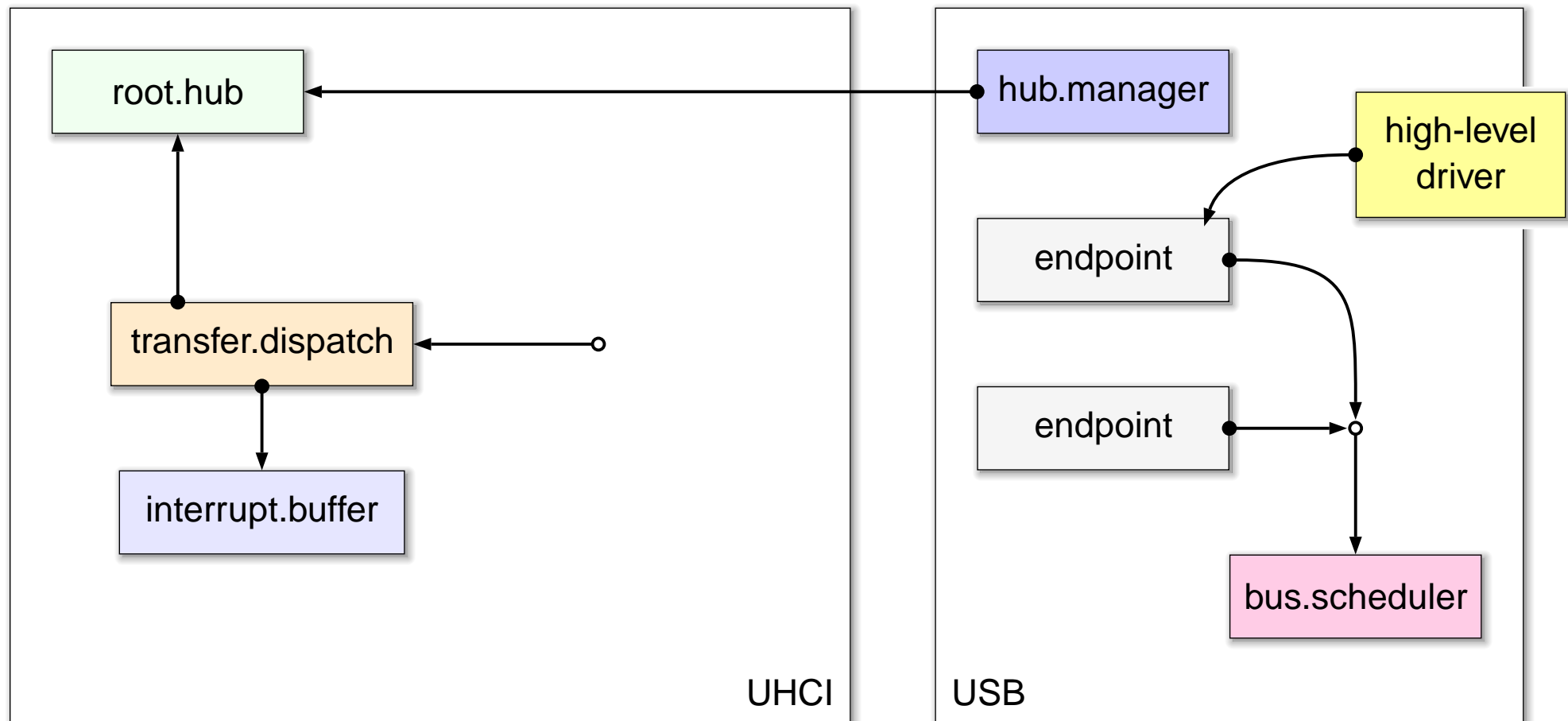
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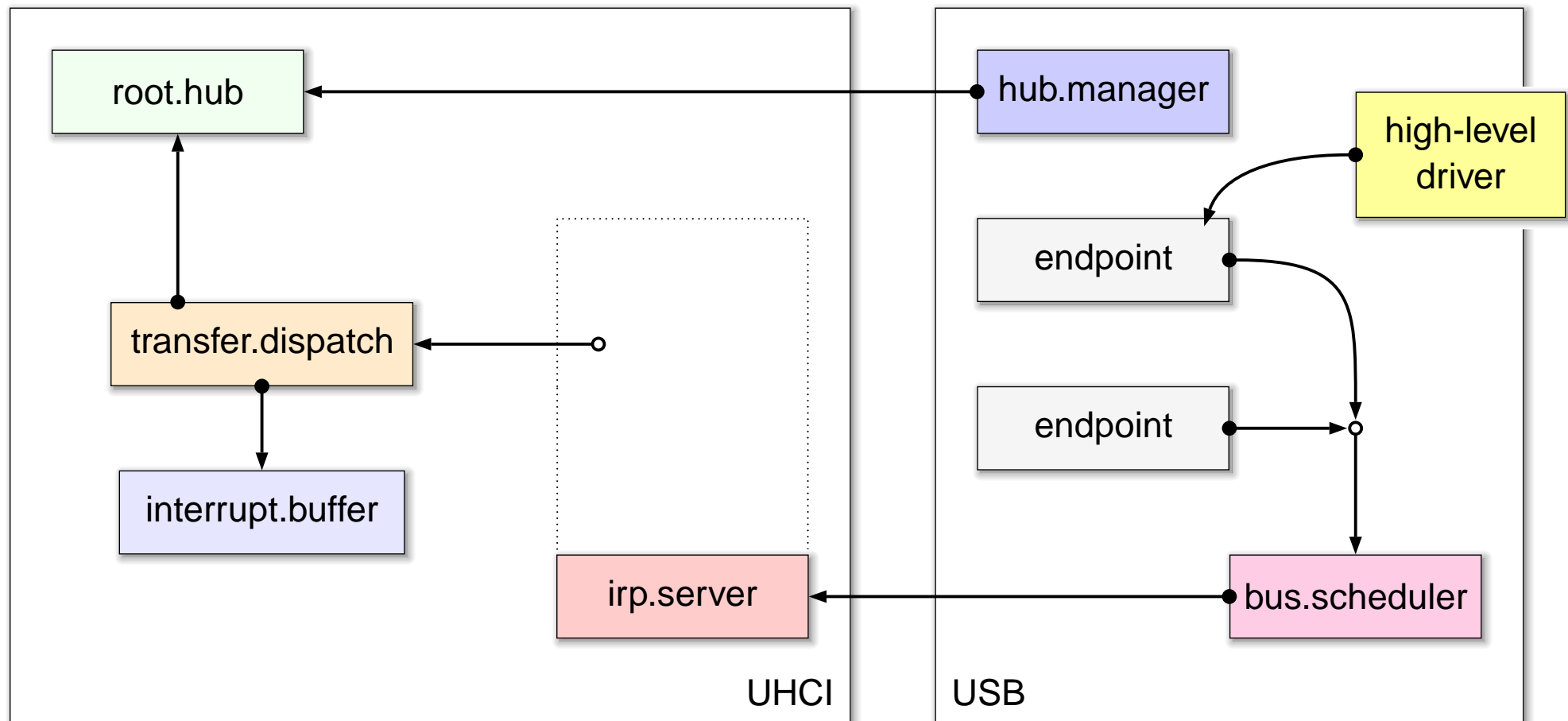
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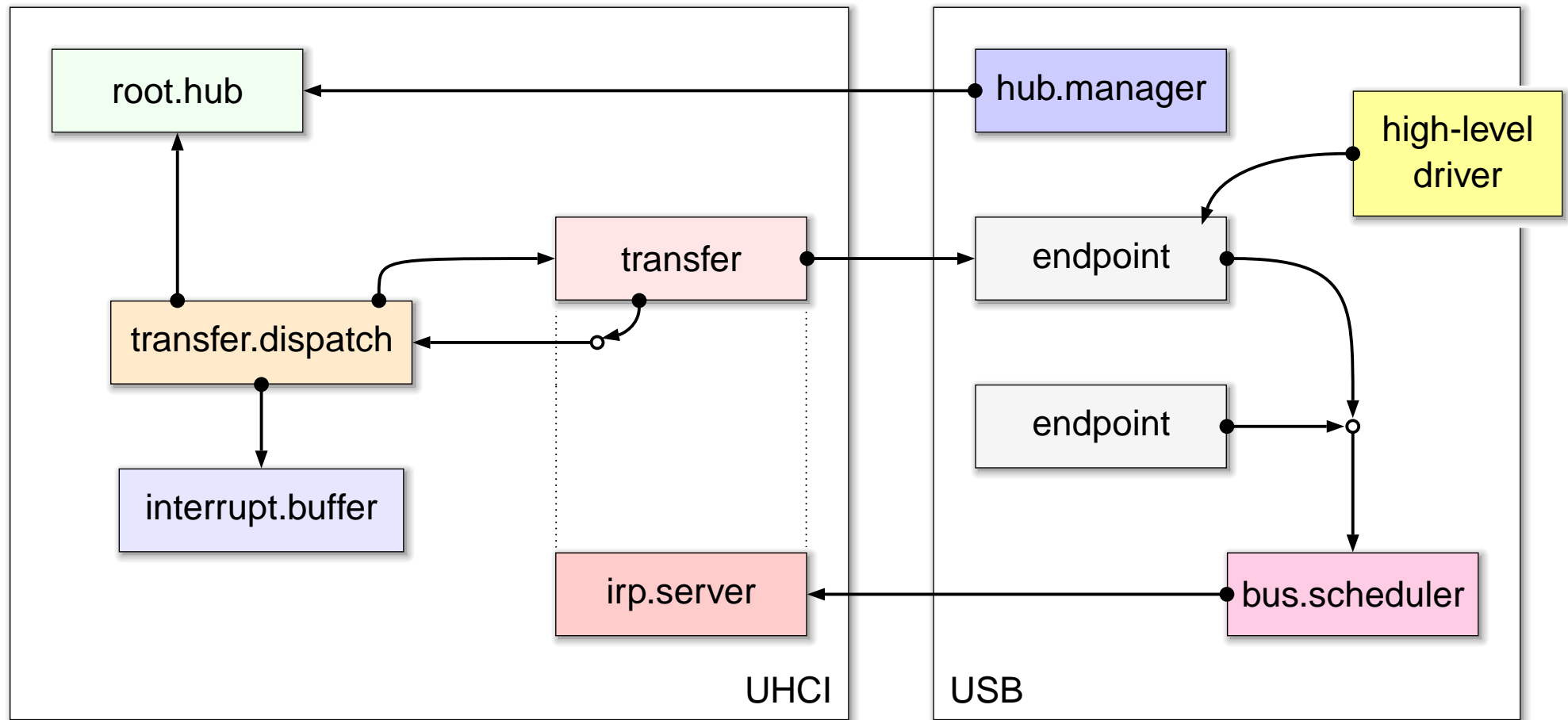
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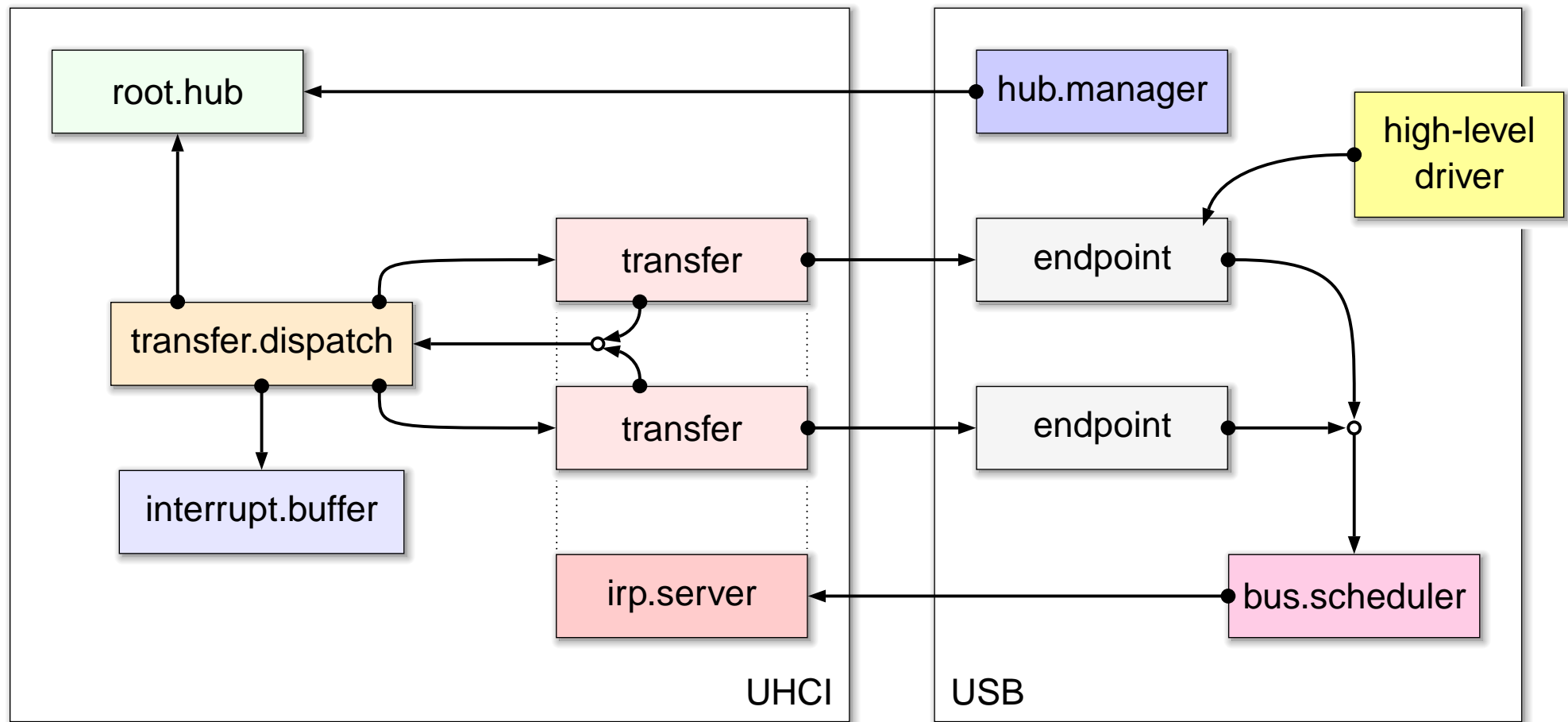
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- Concurrency is a significant advantage for programming — a single device-driver (e.g. USB keyboard) can interact with multiple endpoints without complex coding
- Some care required in shut-down when a device is unplugged
  - dummy processes **forked** to service requests, preventing deadlock

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- Questions?