A Process Oriented Approach to USB Driver Development

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University of Kent

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

A Brief Introduction to occam-pi

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- **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 **π-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-π suitable for building many types of system, both simple and complex

Simple Processes

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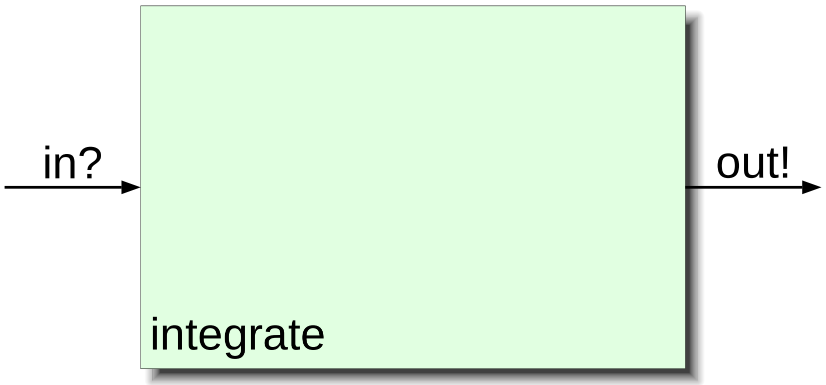

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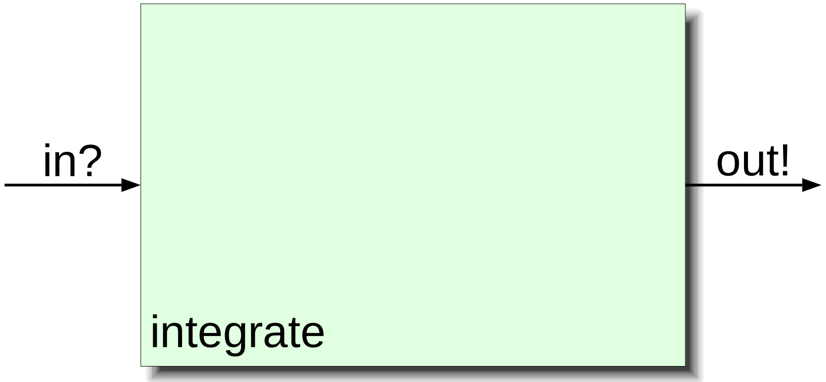


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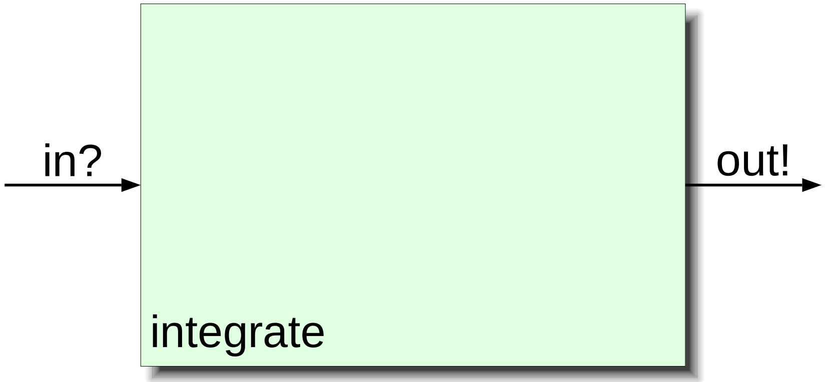


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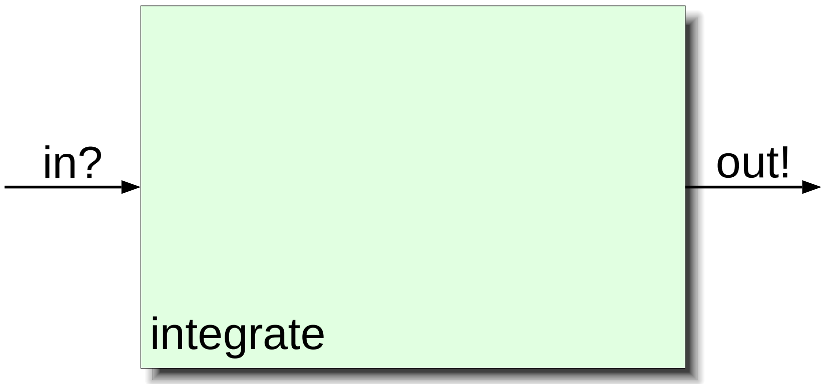

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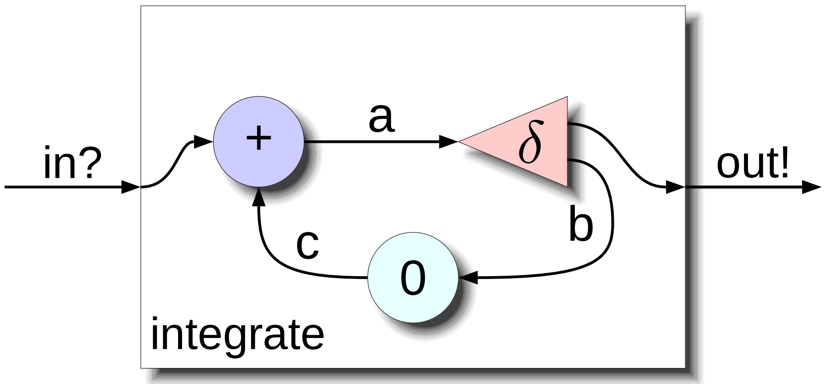


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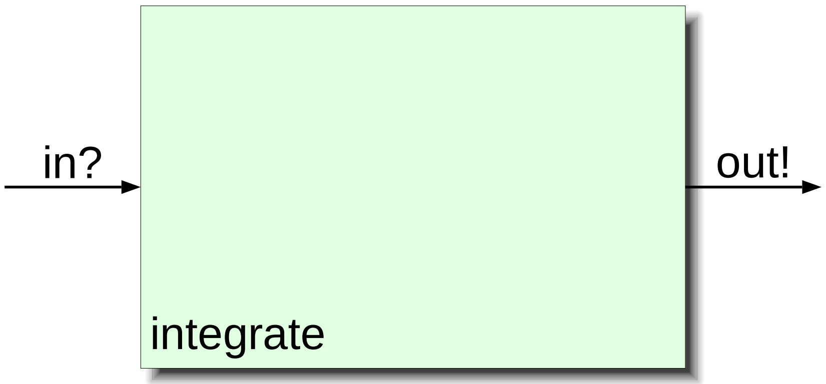


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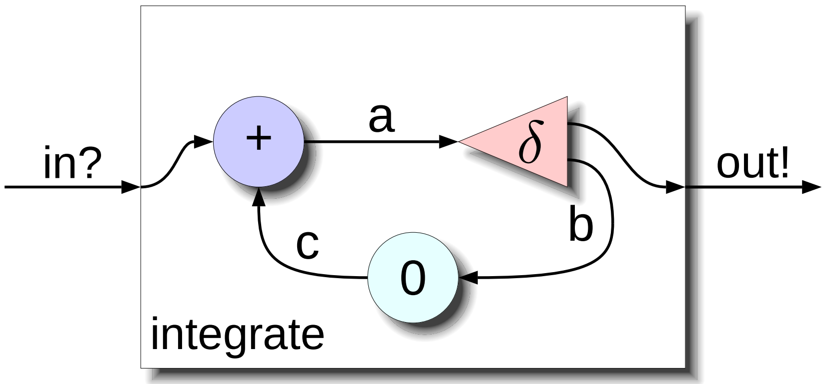


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PROC integrate (CHAN INT in?, out!)
  CHAN INT a, b, c:
  PAR
    plus (in?, c?, a!)
    delta (a?, out!, b!)
    prefix (0, b?, c!)
:
```

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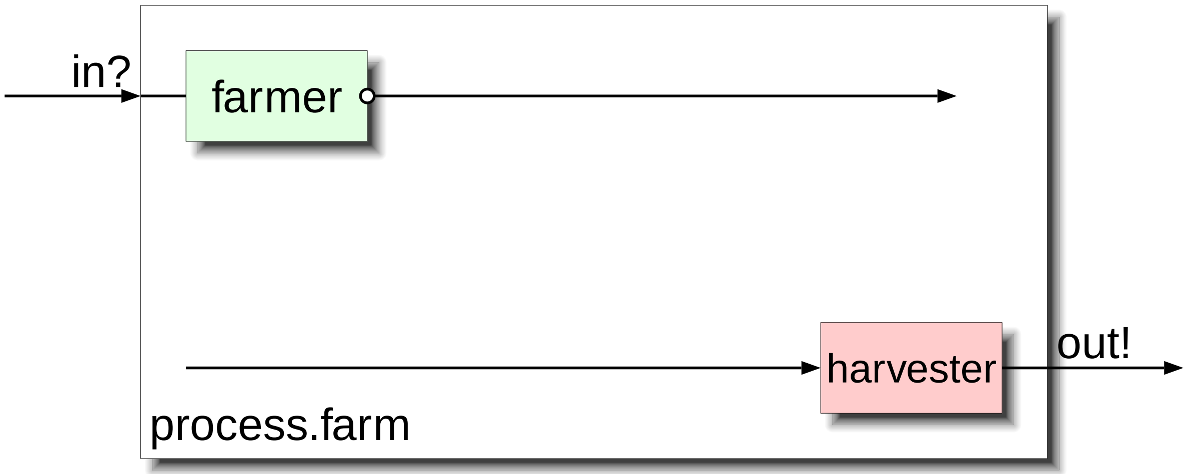

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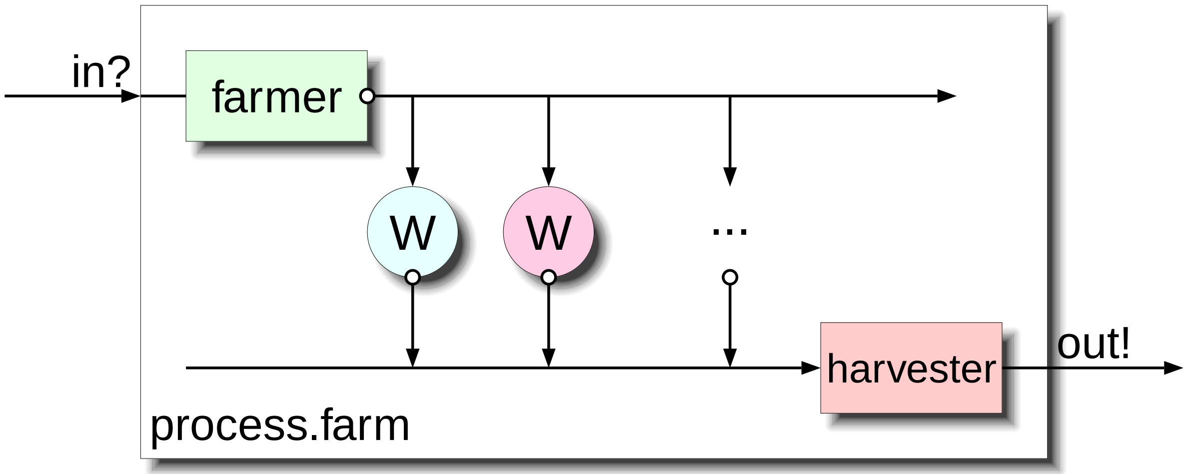

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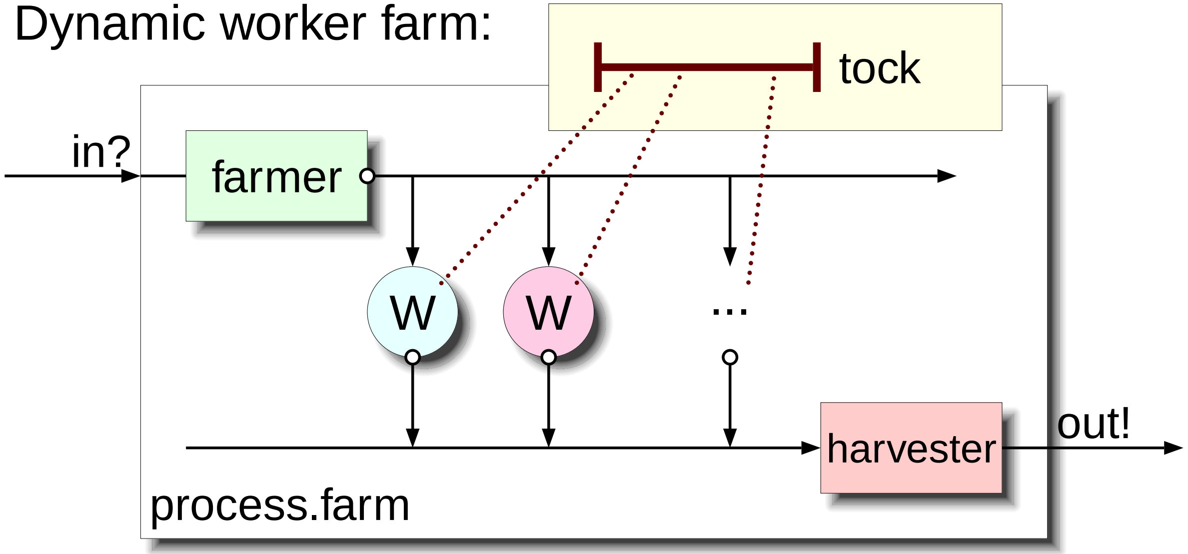

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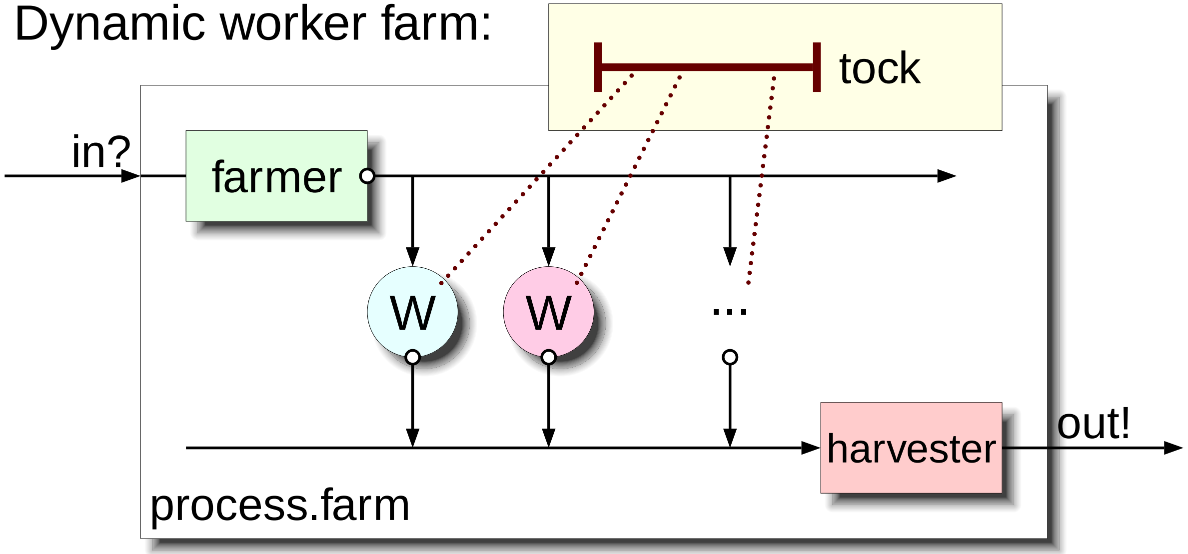

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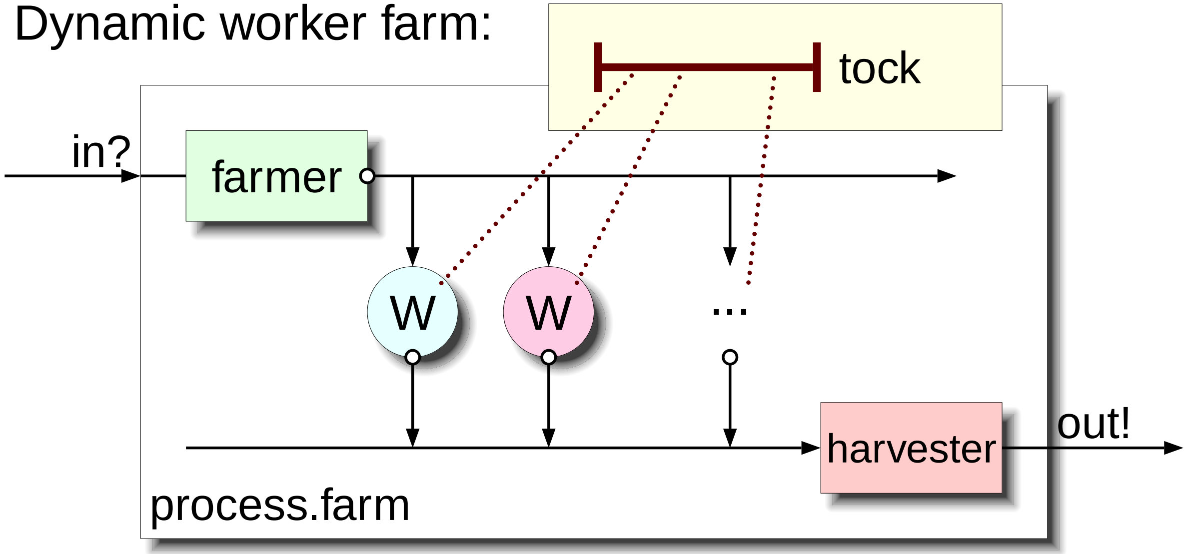

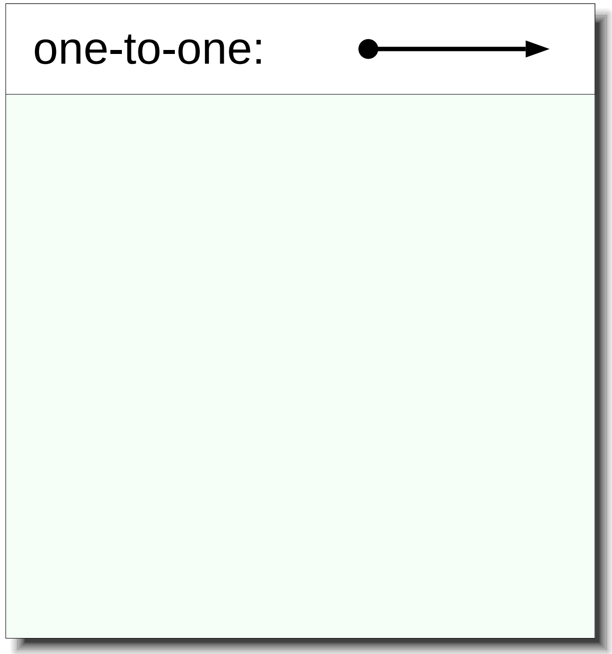

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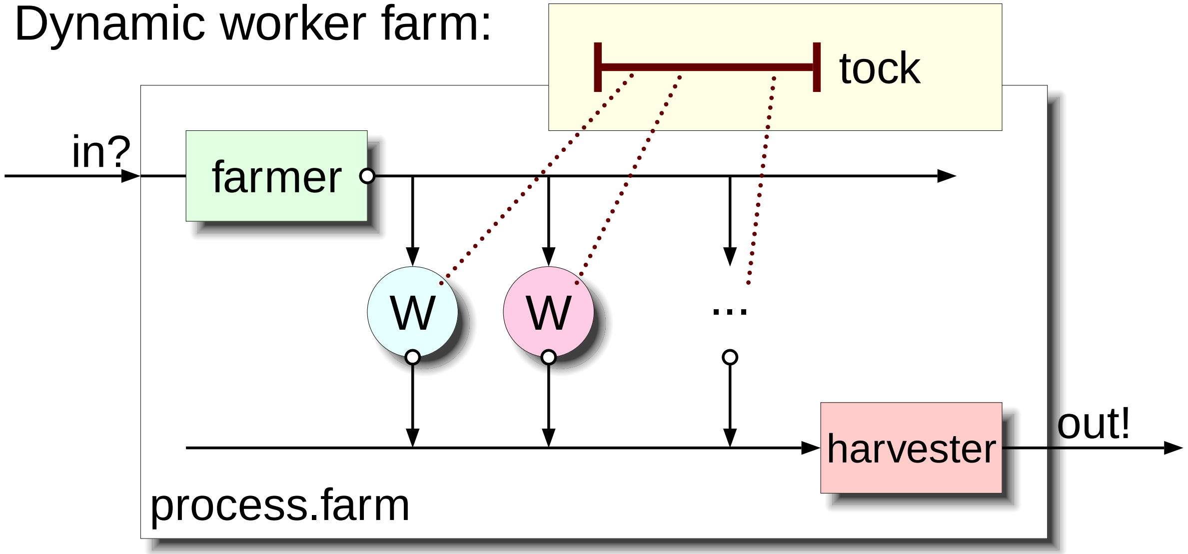

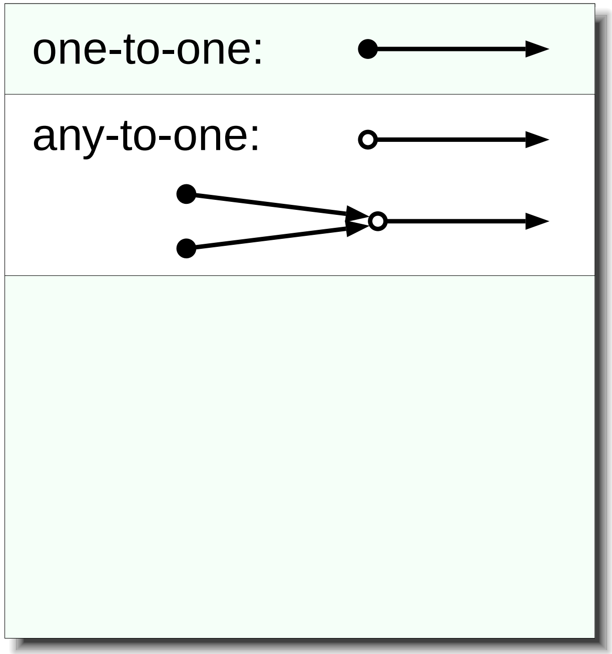

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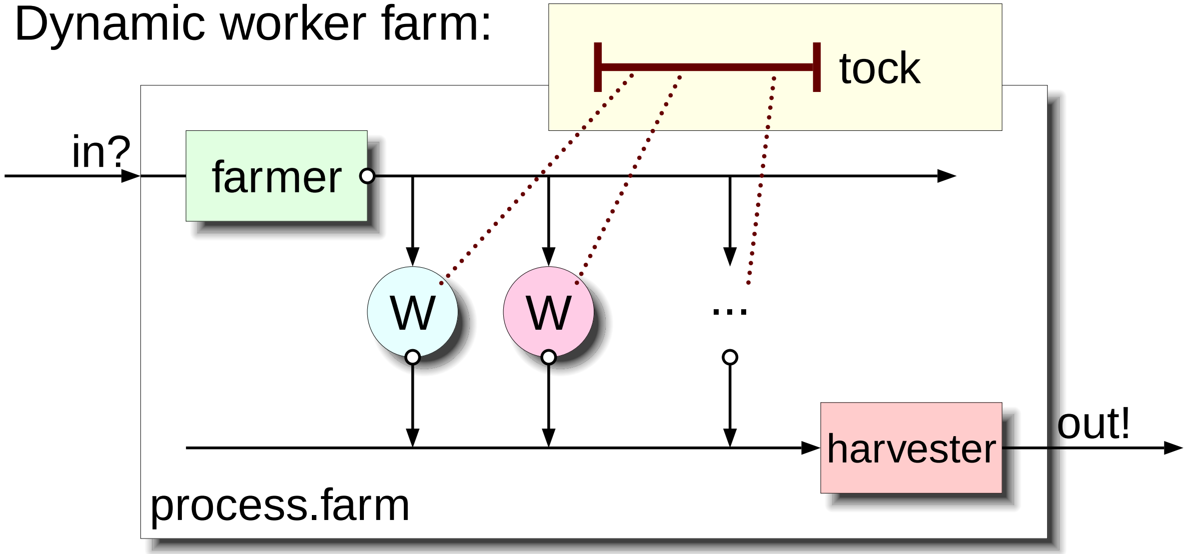

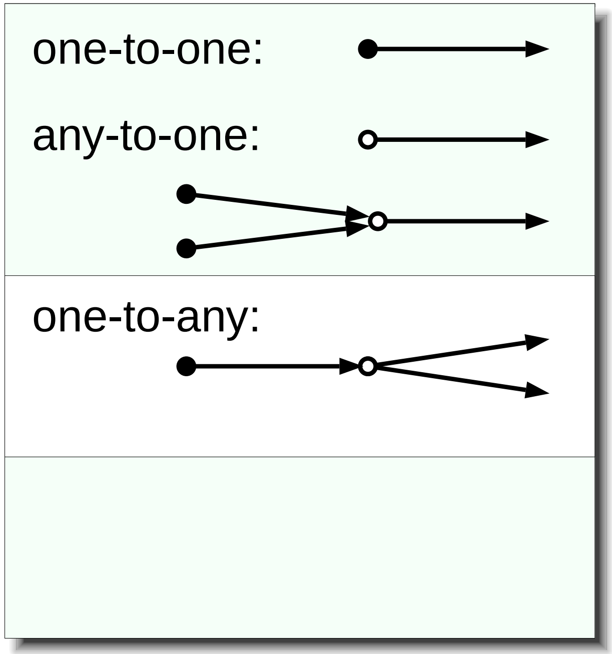

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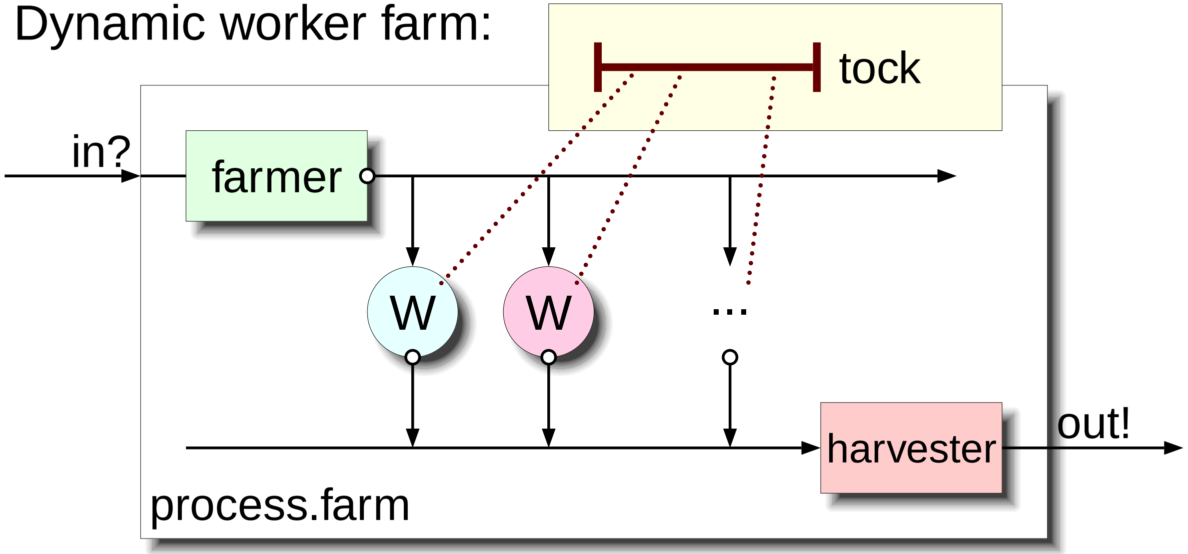

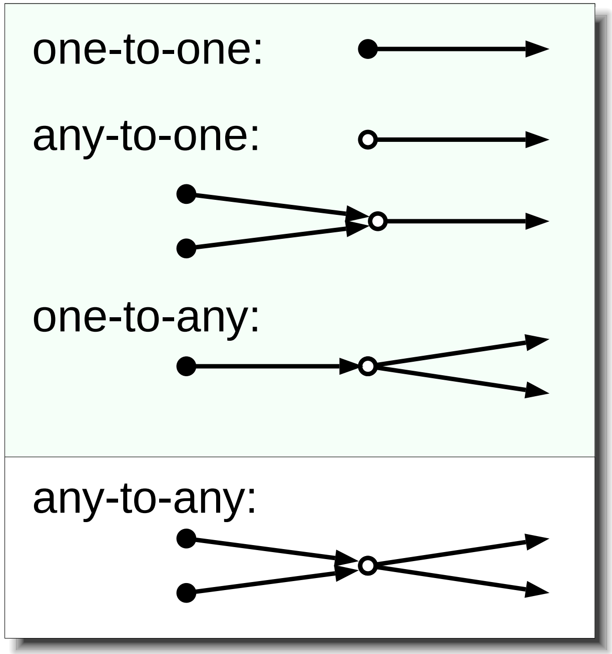

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- The memory footprint for occam-π parallel processes is comparatively small:
  - can handle **millions** of simple processes on a modern desktop PC

The RMoX Operating System

The RMoX Operating System

- RMoX is an operating-system built using occam-π, 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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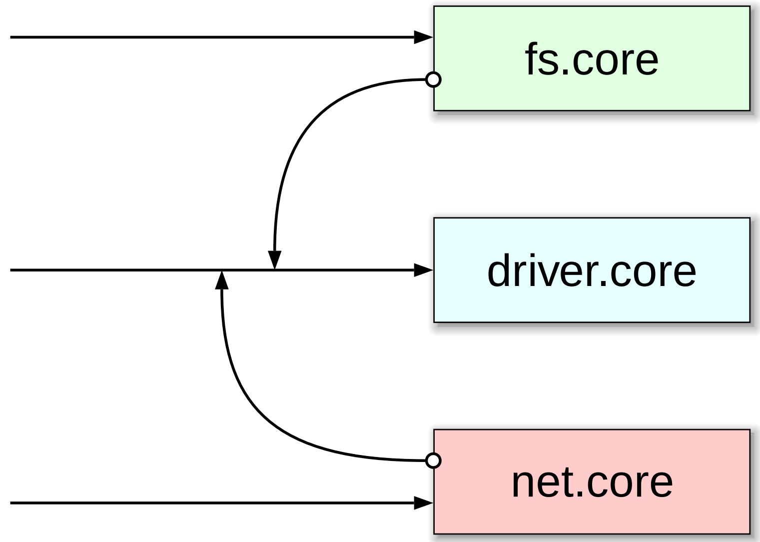

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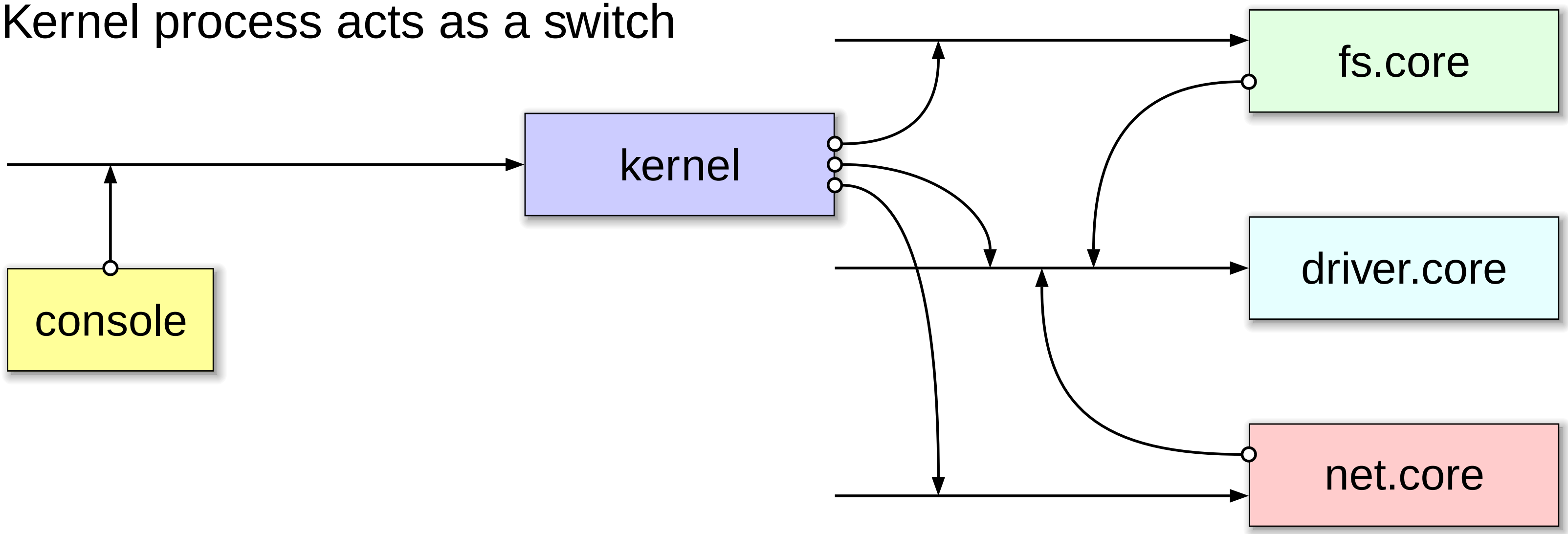

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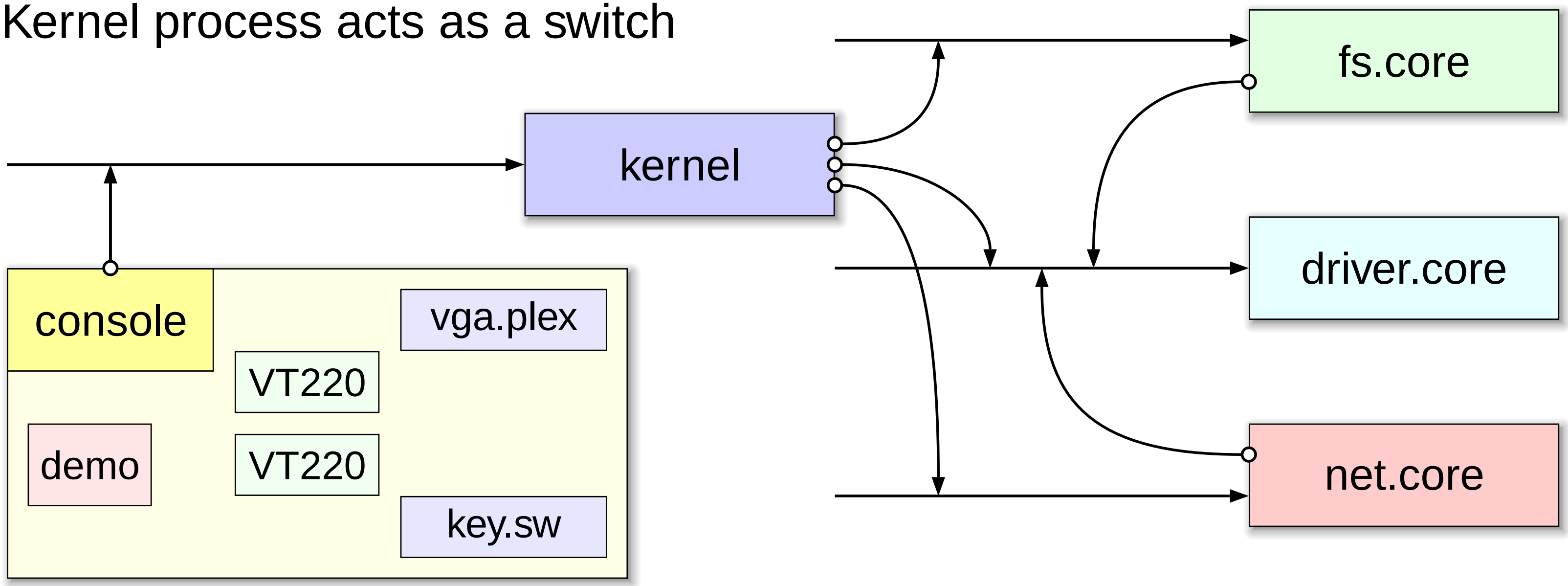

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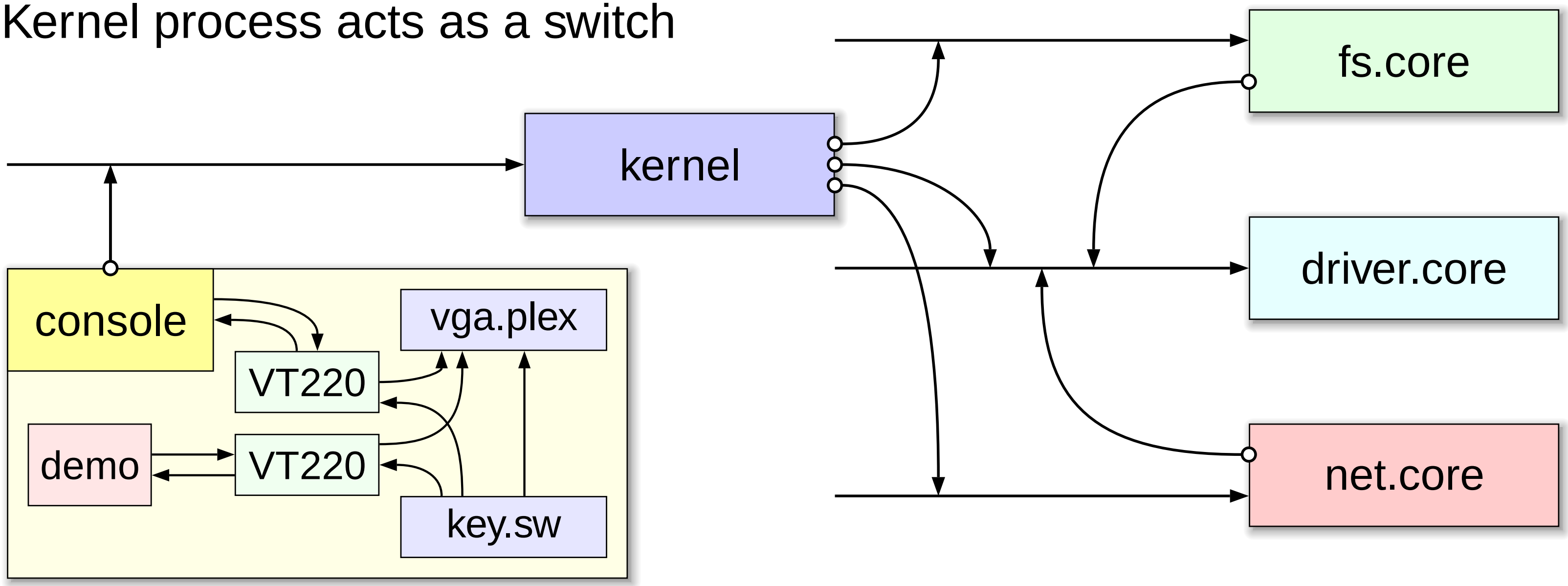

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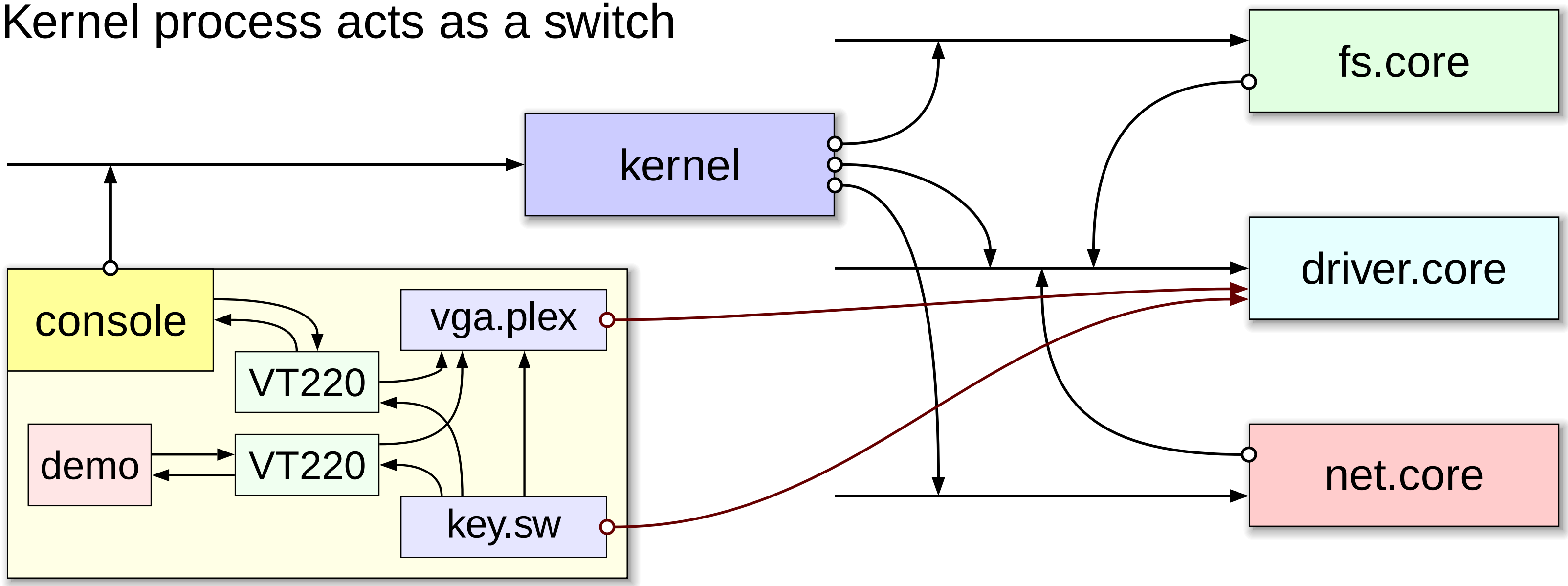

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- Connections within dynamically formed and dismantled as required

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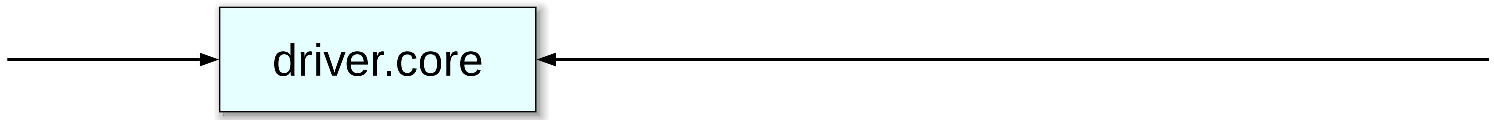
- The various “core” components utilise internal concurrency



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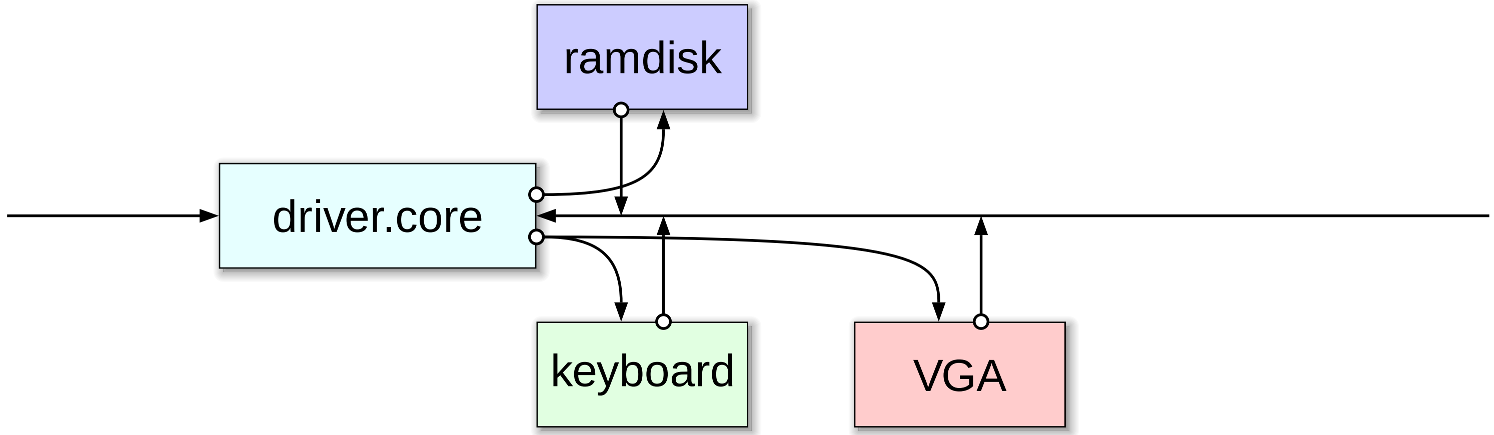

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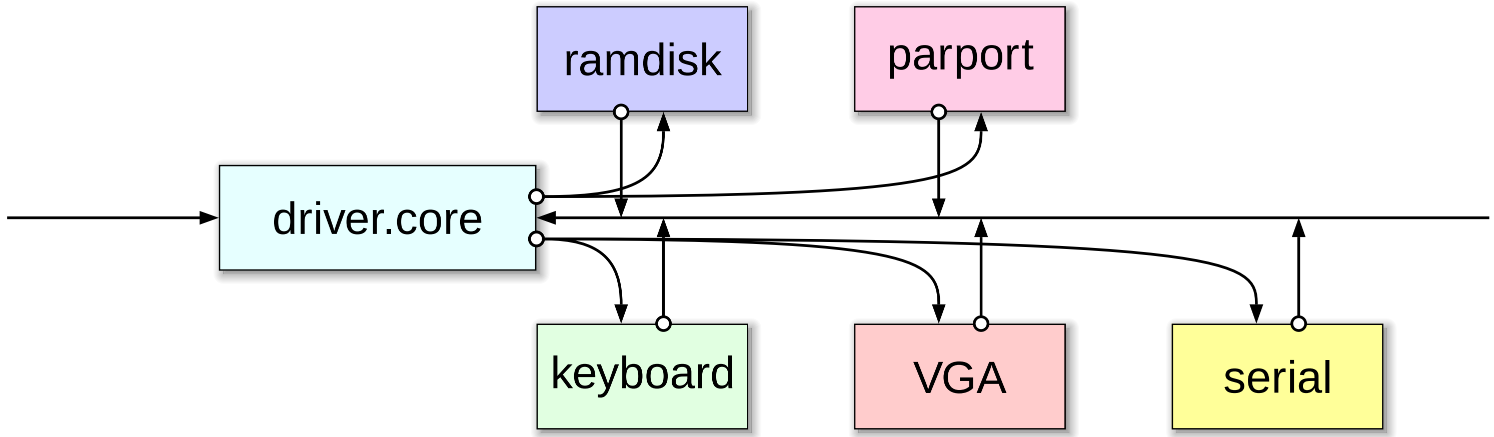

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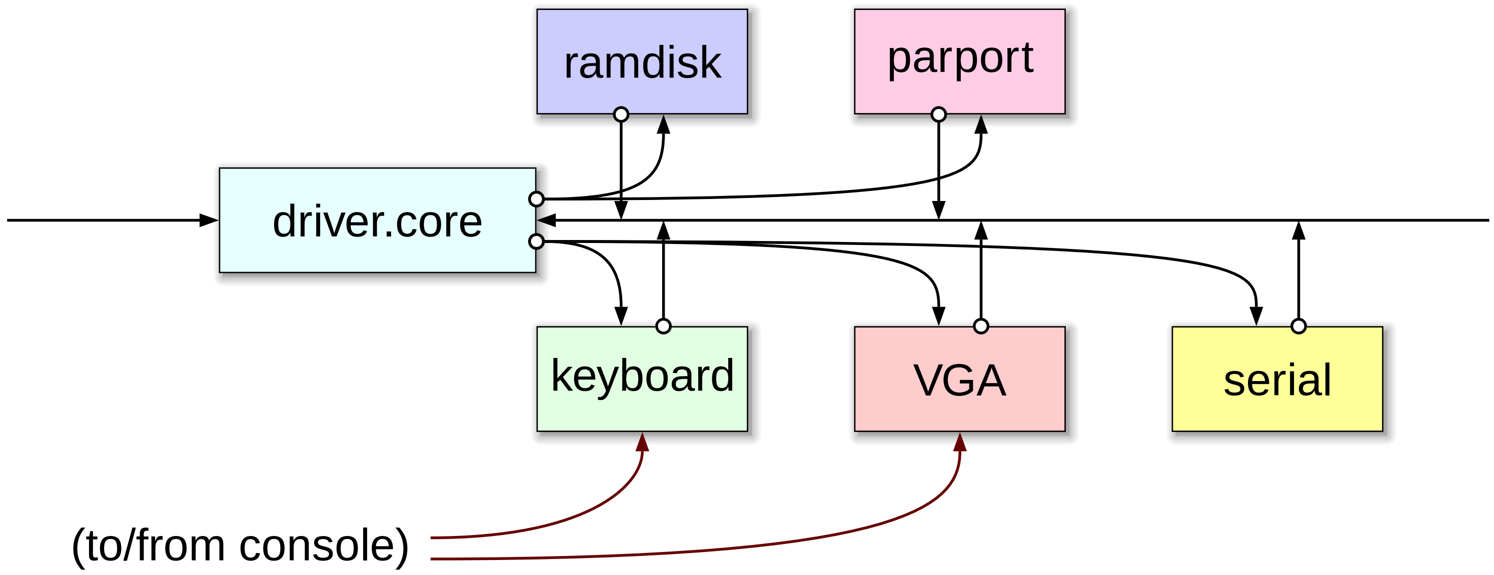

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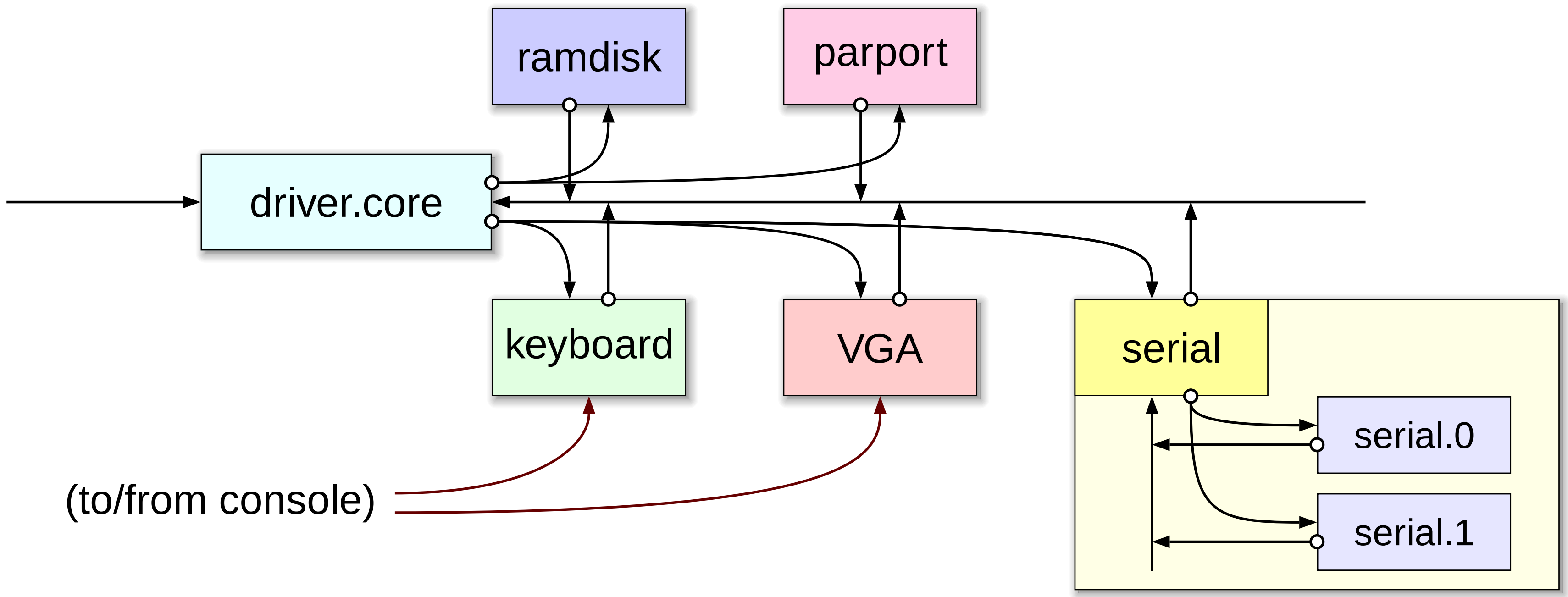

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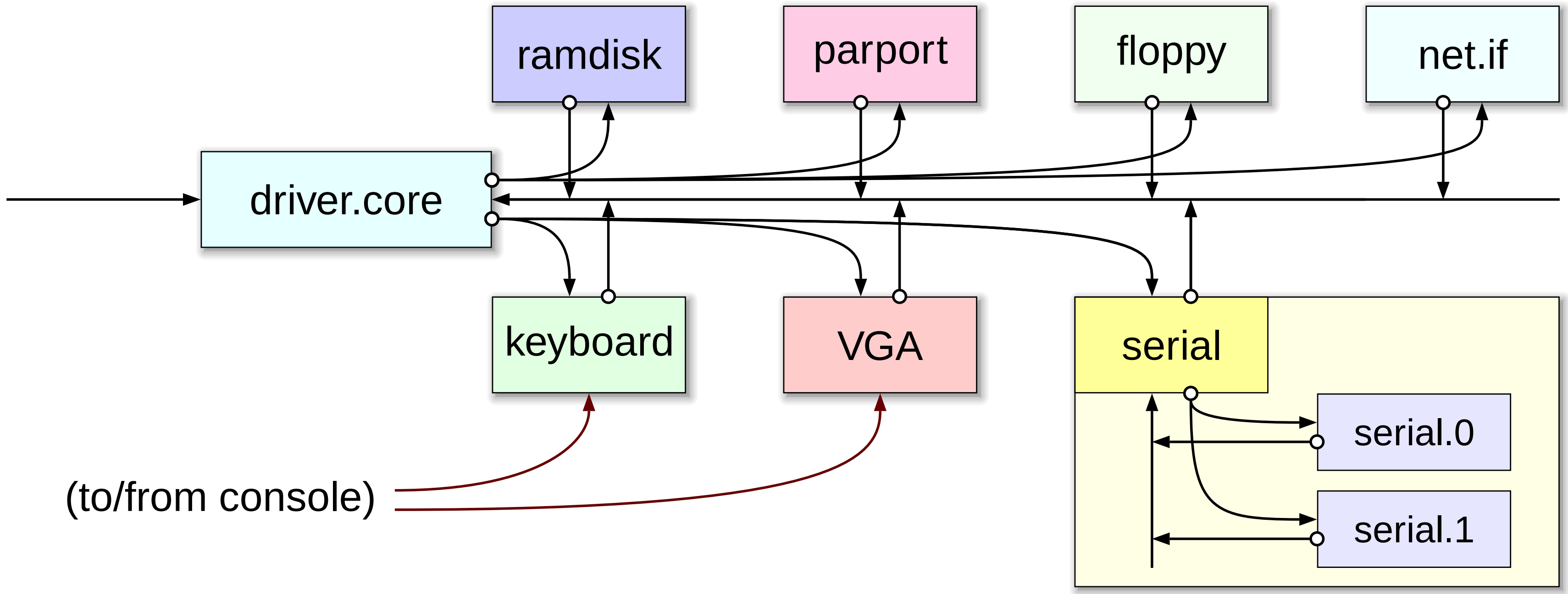

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- Some drivers mostly complete, others under construction

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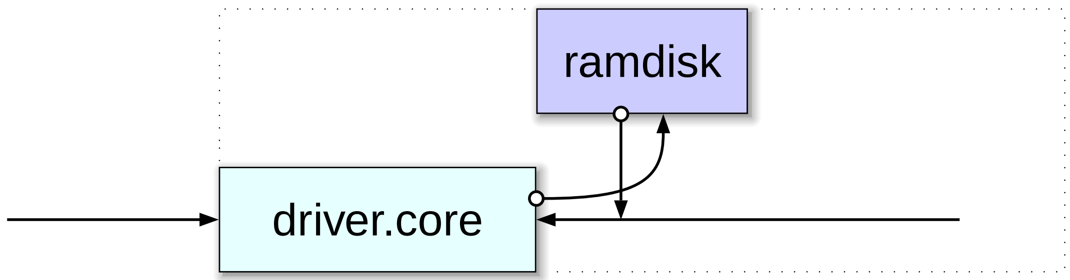

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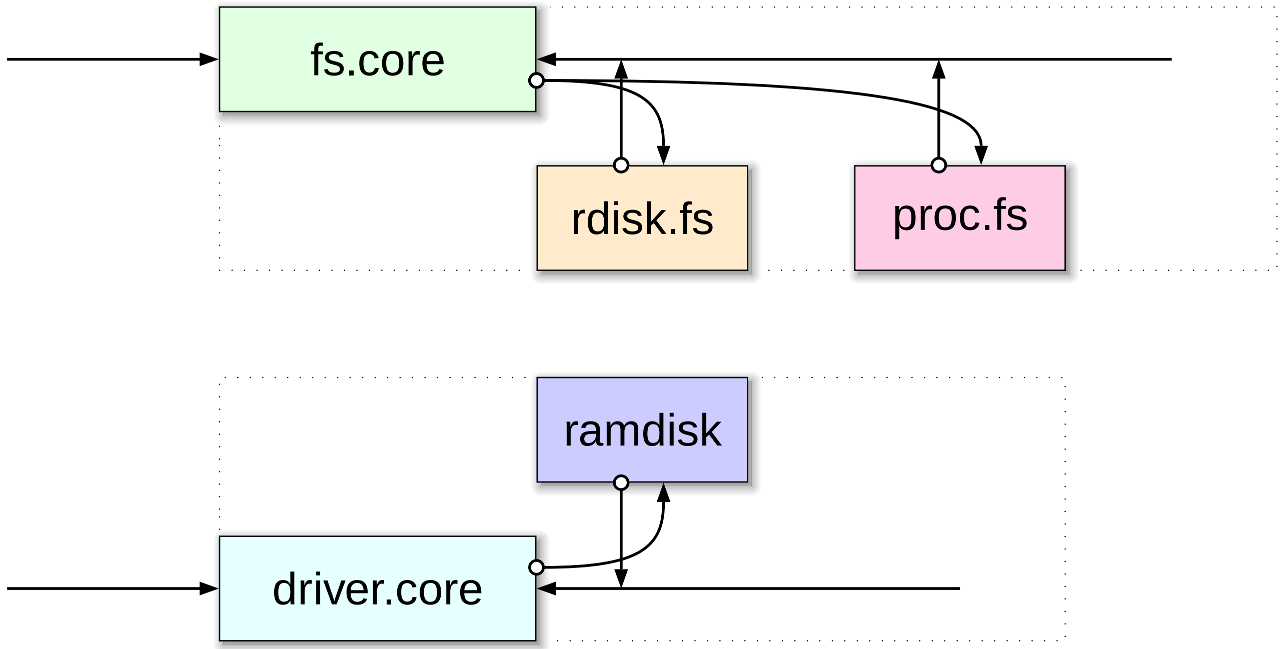

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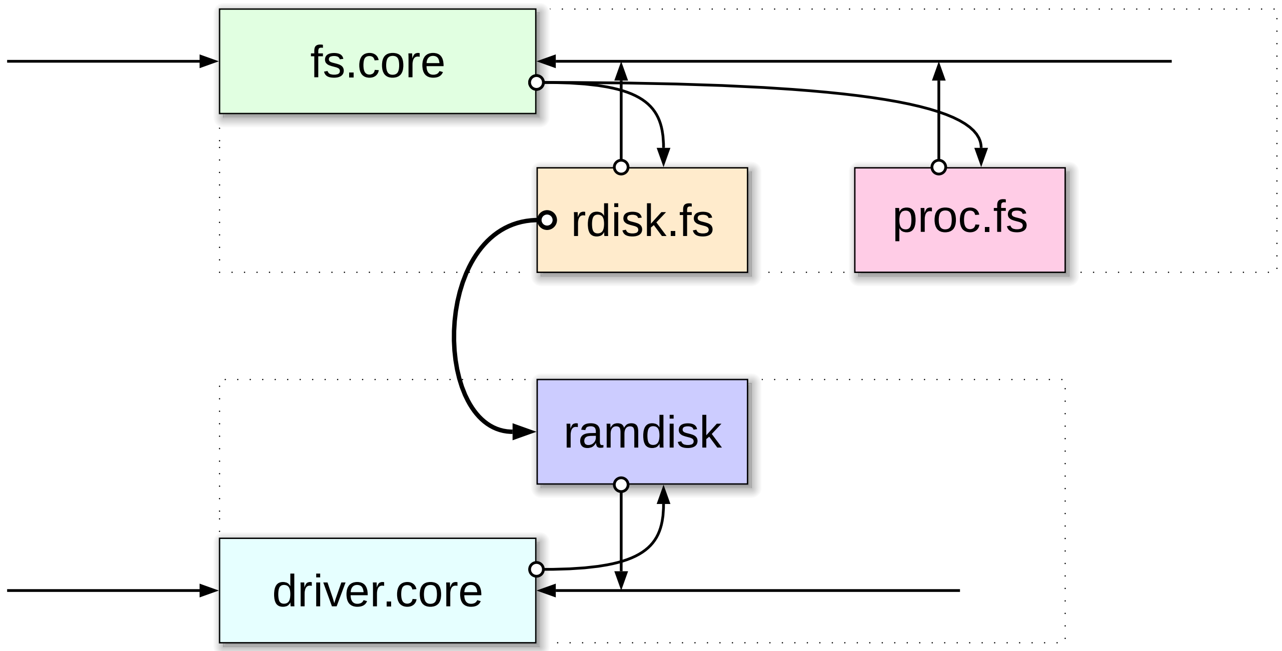

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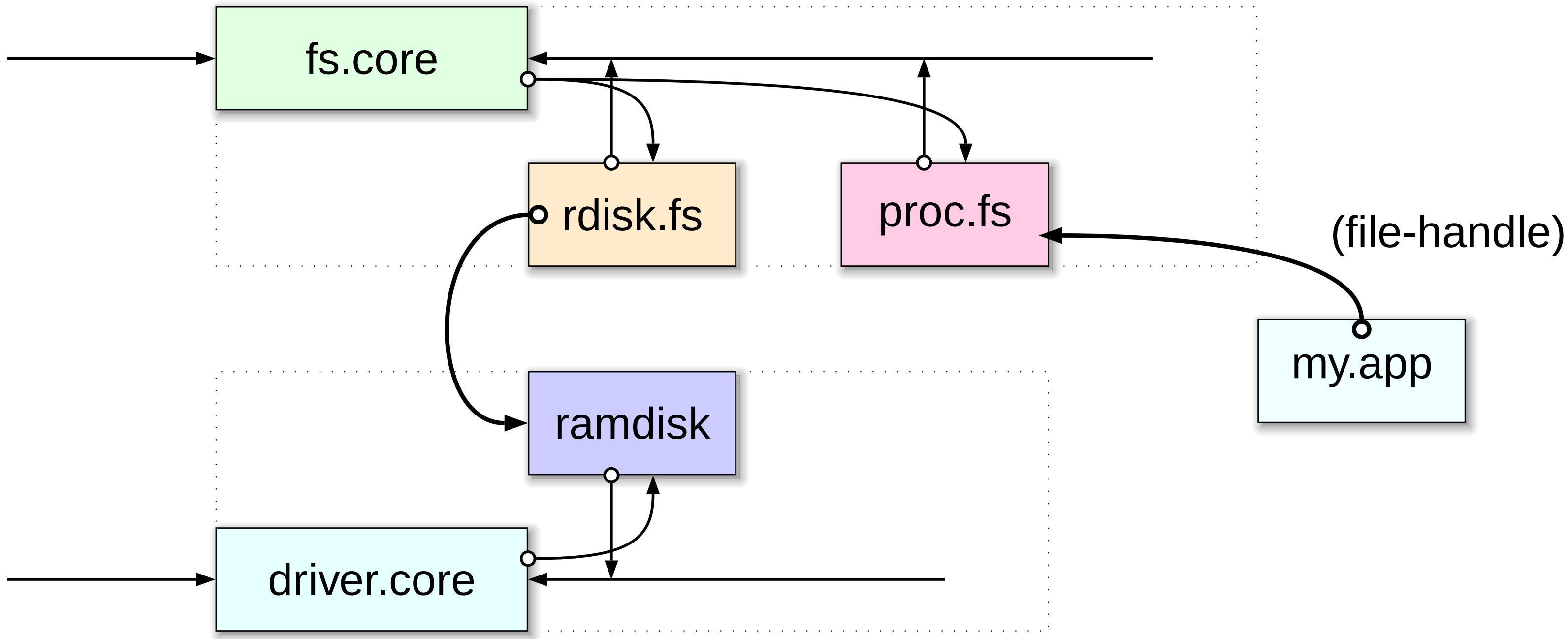

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- Process networks for things such as PCI and USB drivers reflect hardware organisation — not a complex mass of sequential code!

USB Hardware

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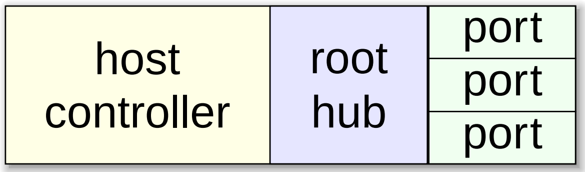

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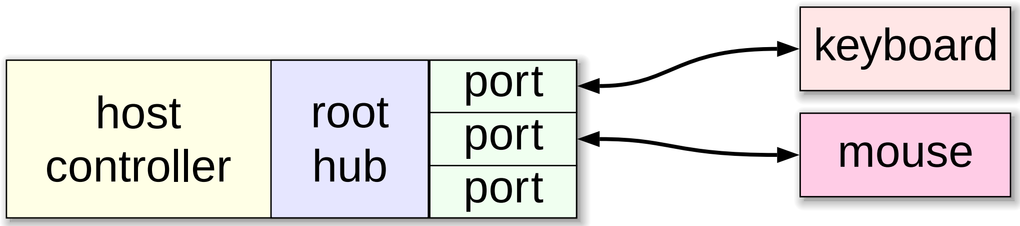

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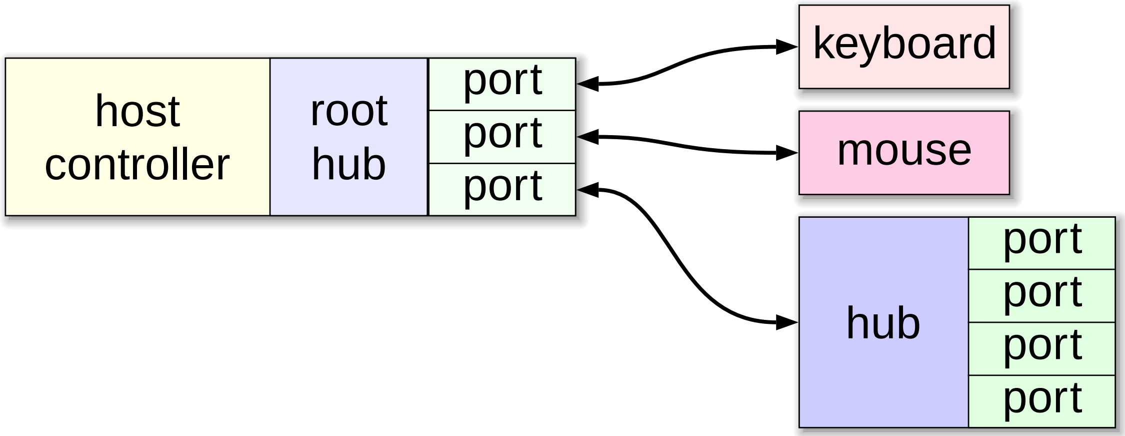

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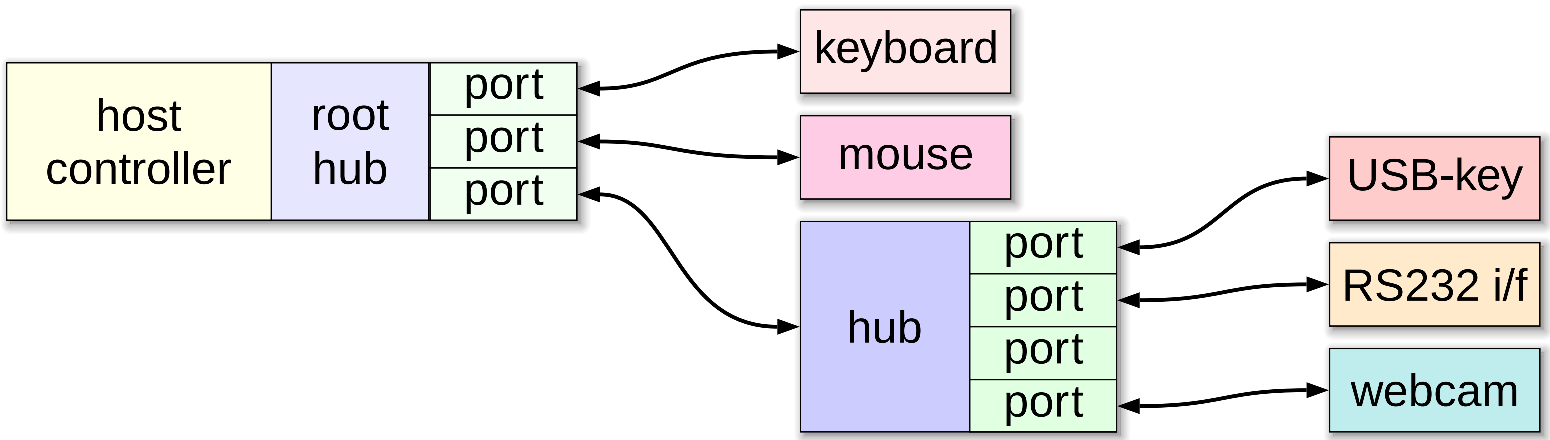

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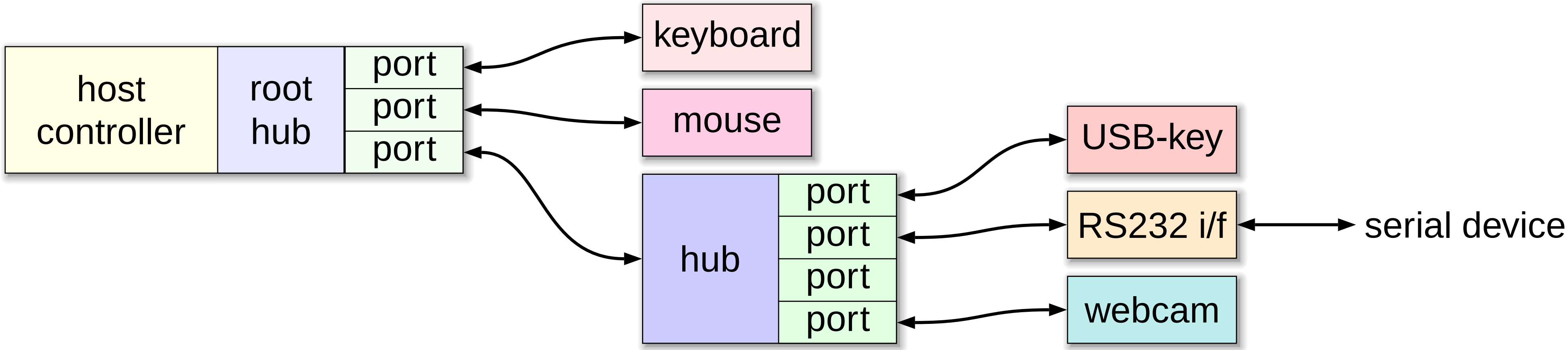

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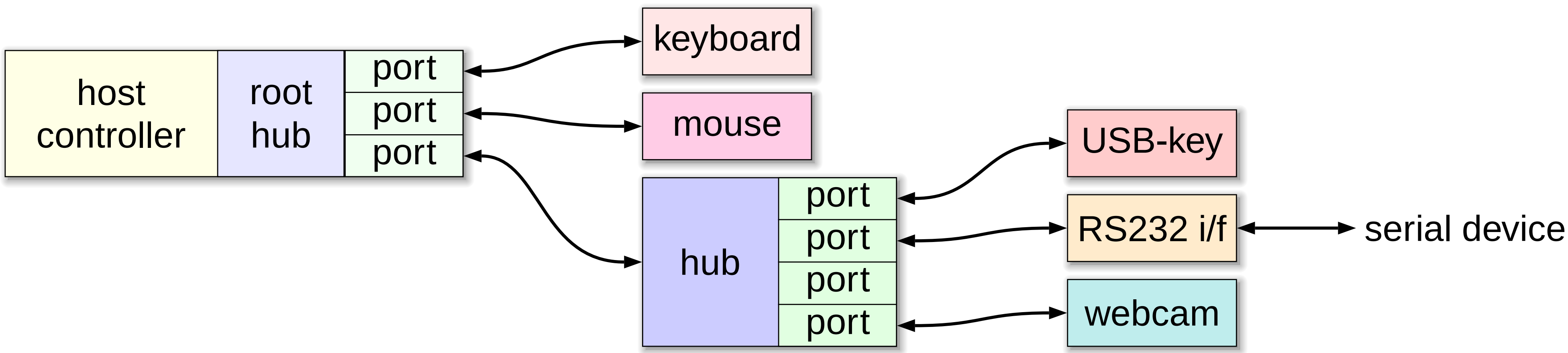

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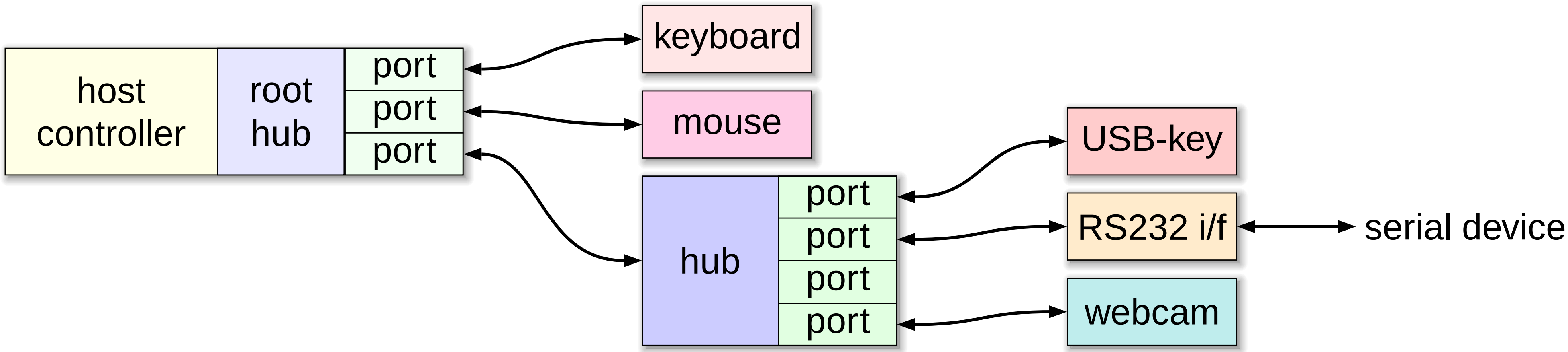

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- Range of devices is complex: simple peripherals, legacy interfaces, networking, ...

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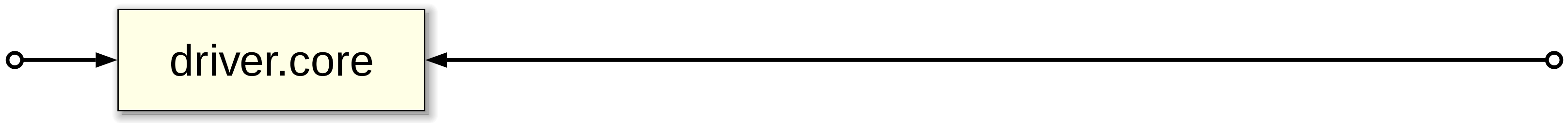

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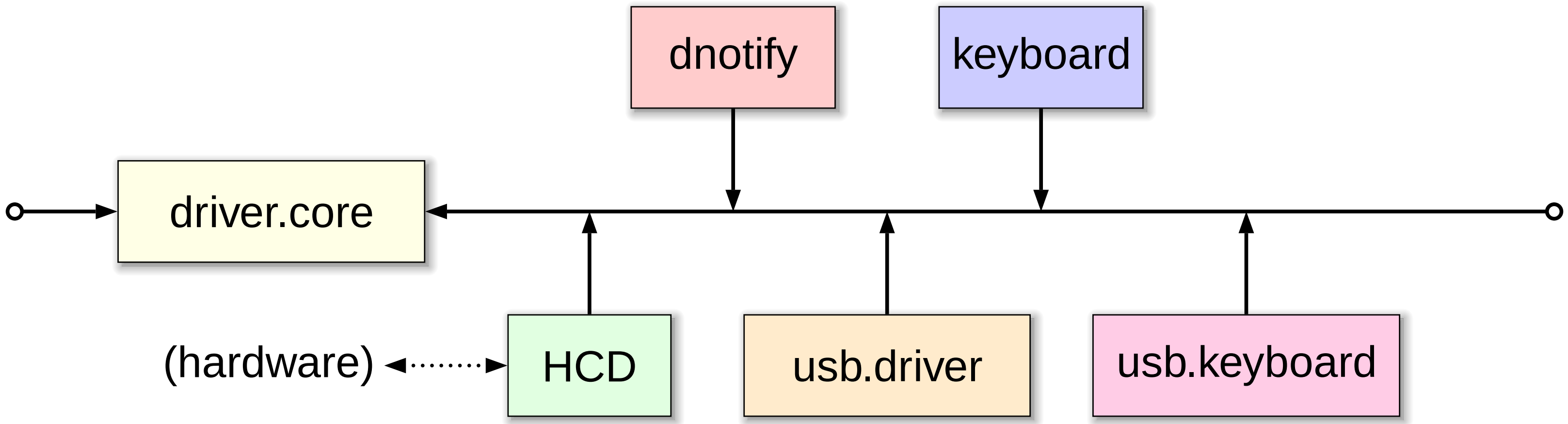

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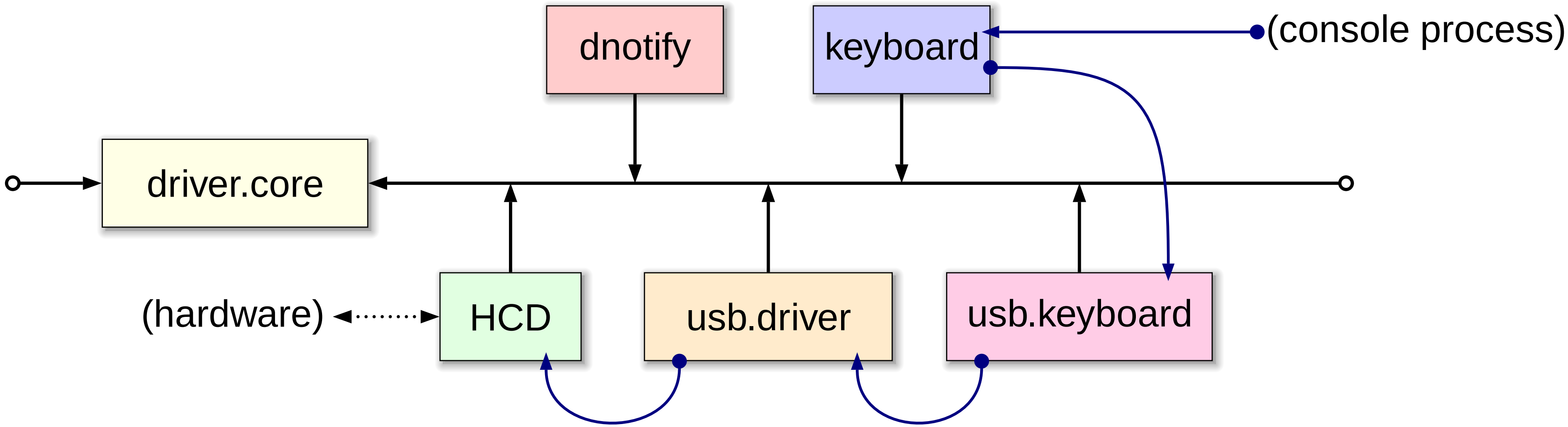

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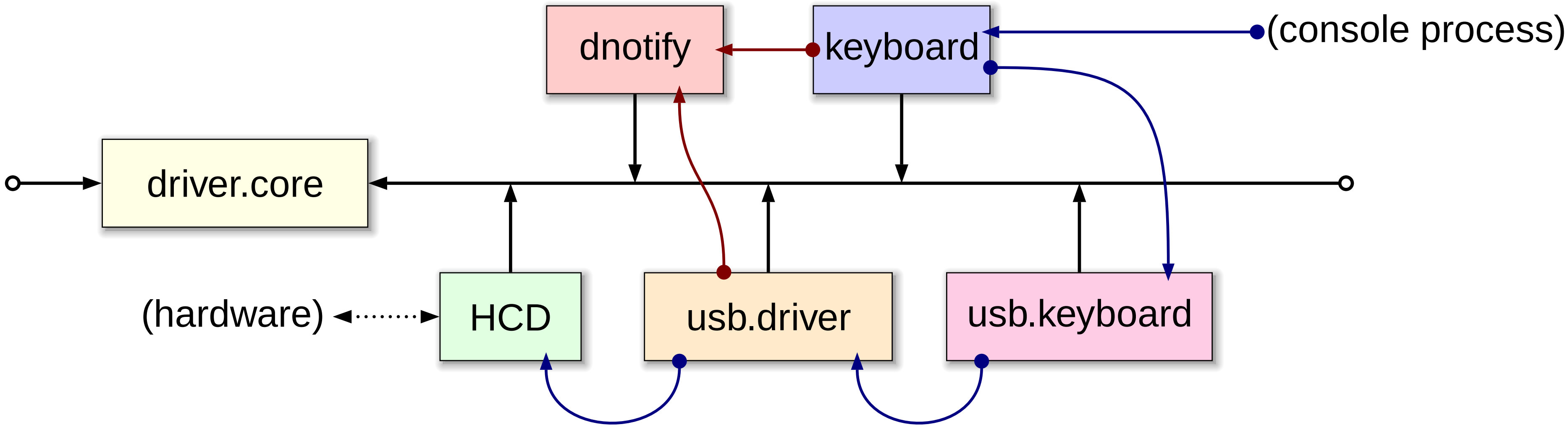

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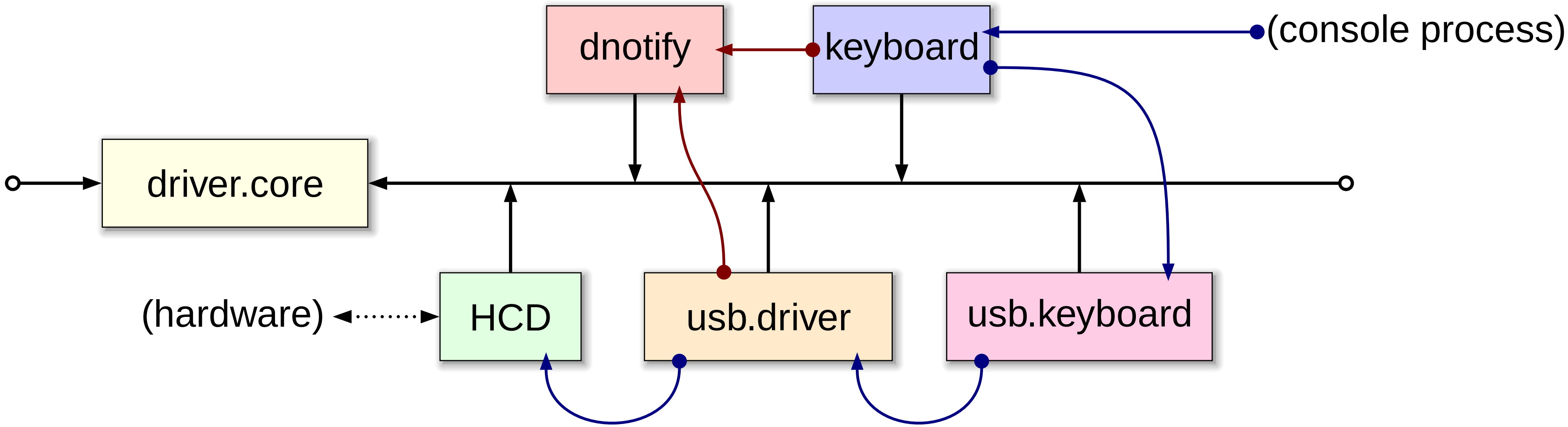

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Process Oriented USB

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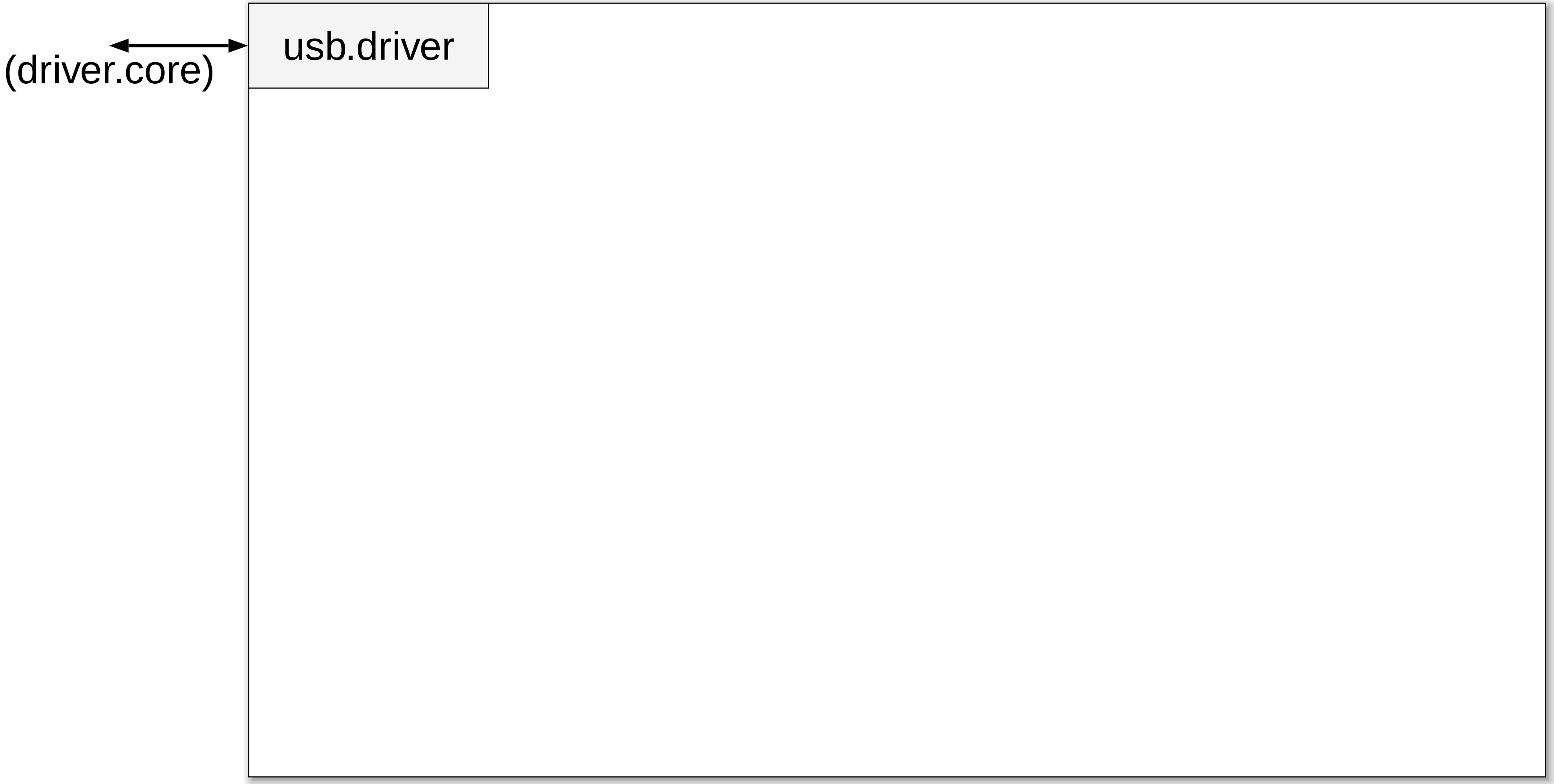

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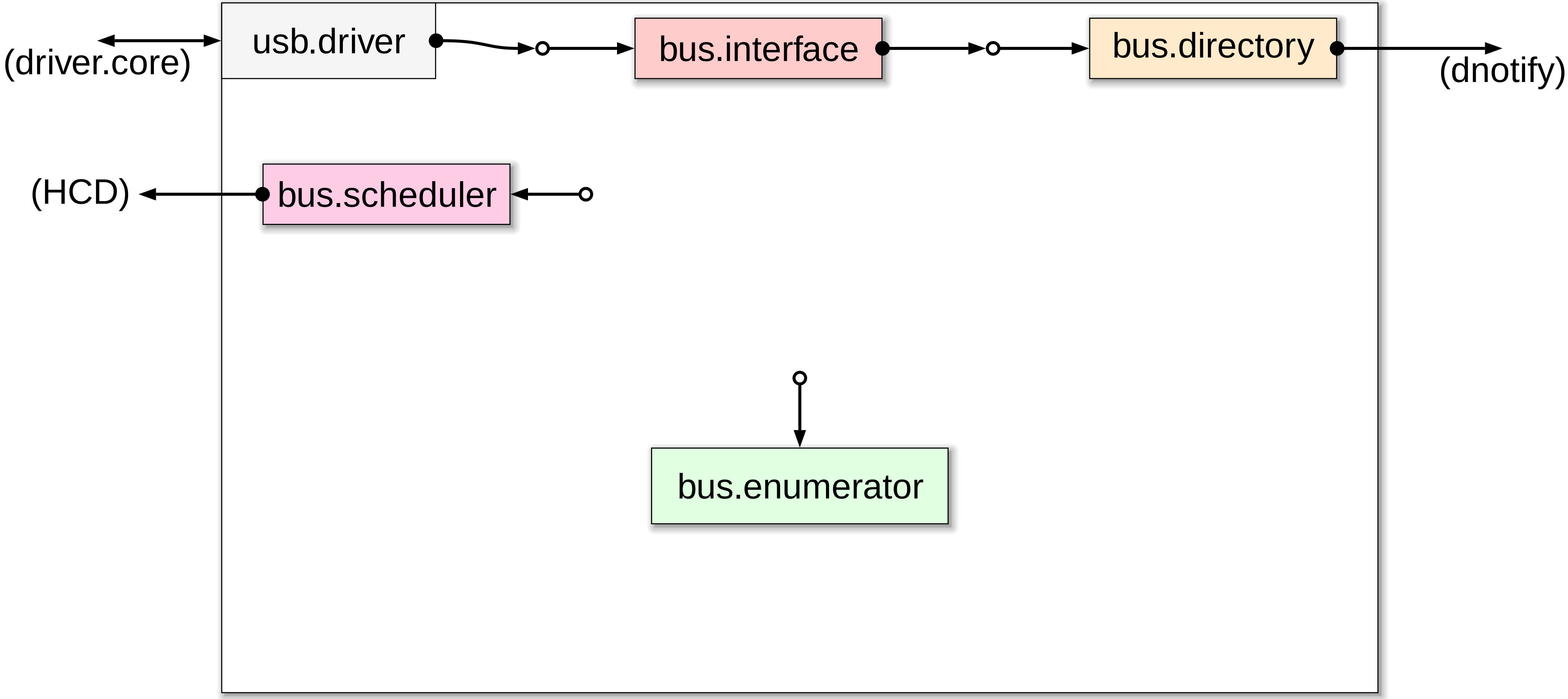

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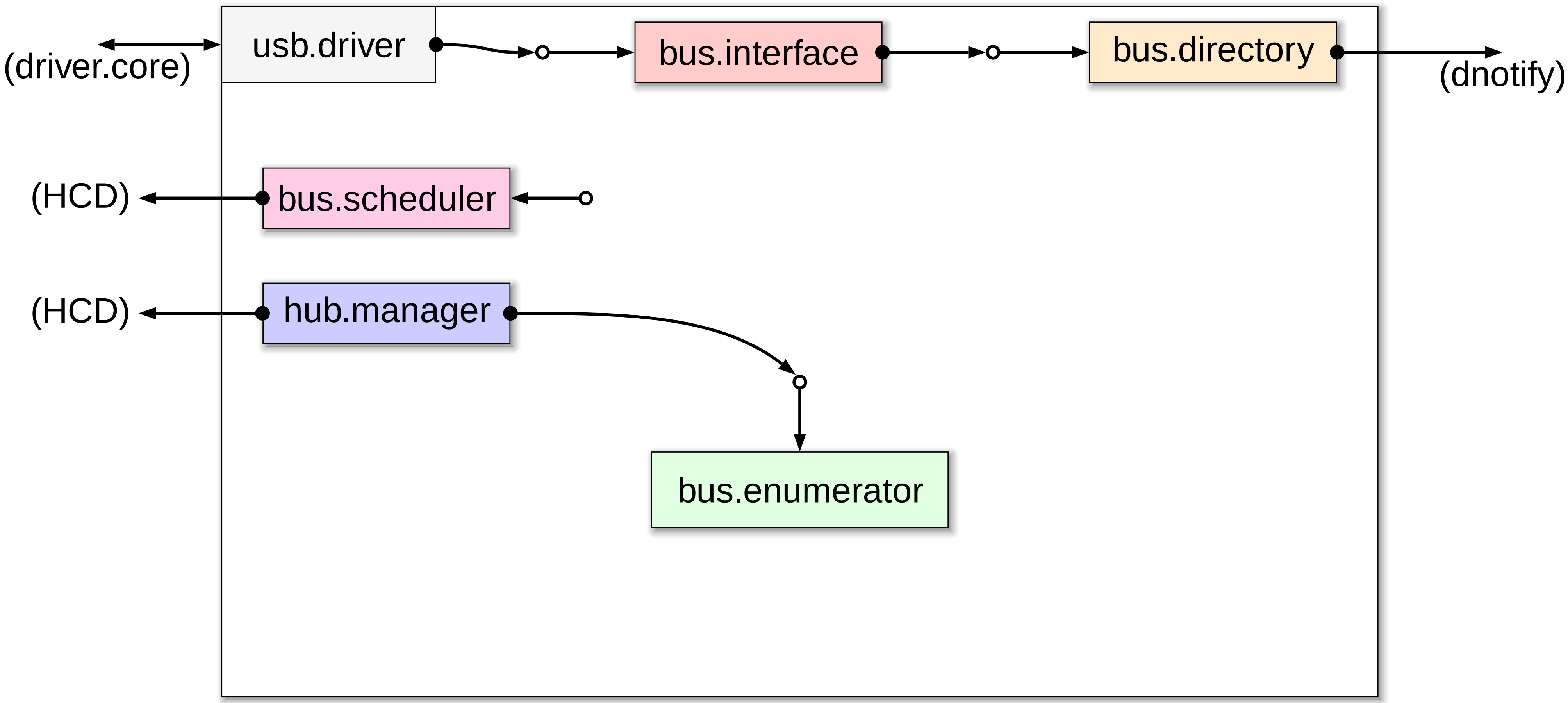

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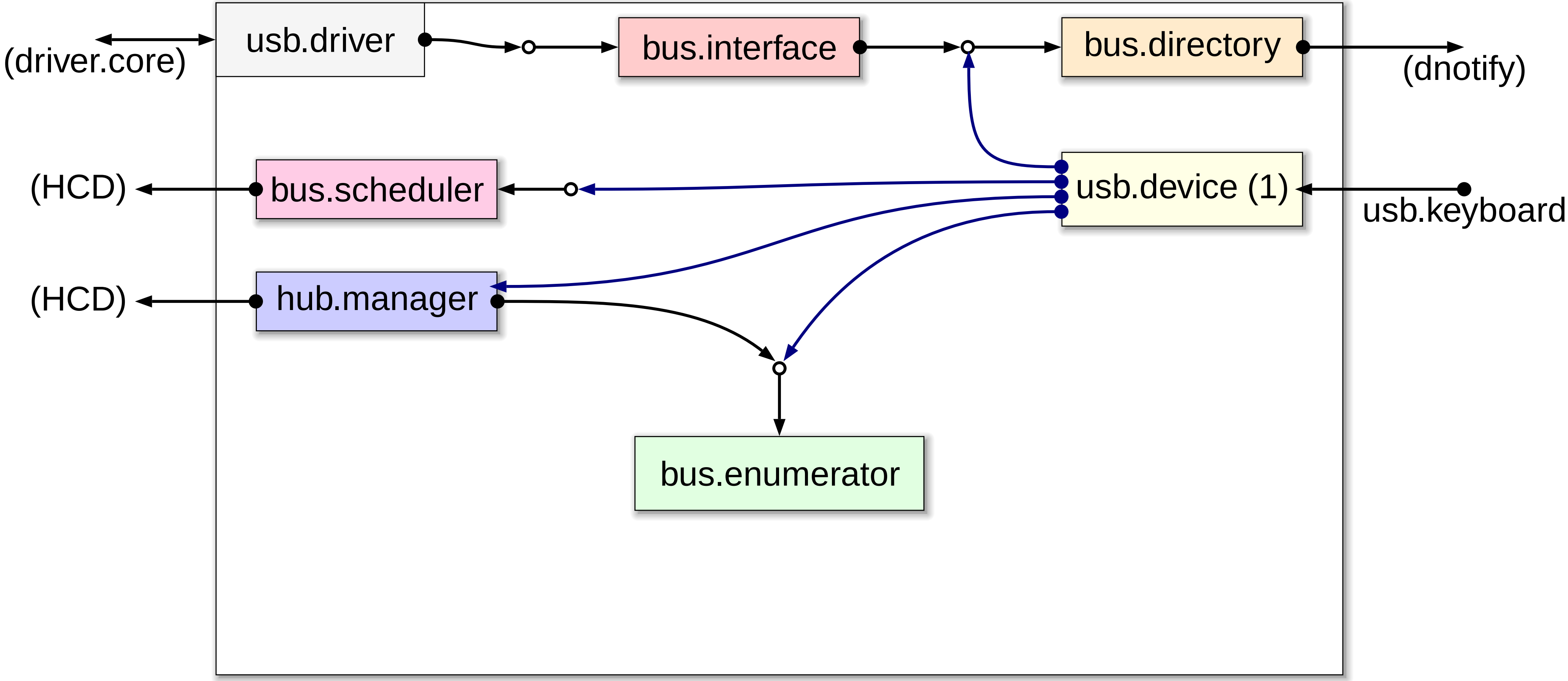

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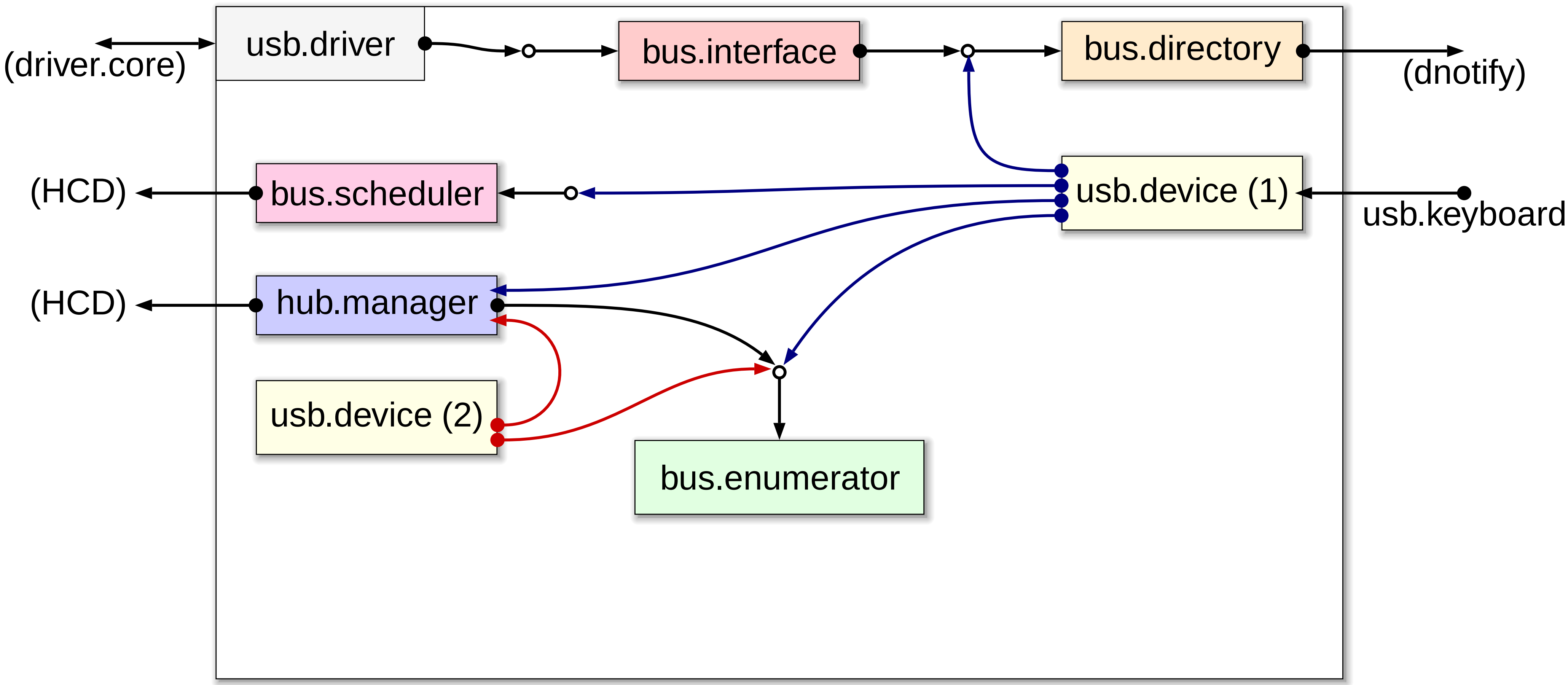

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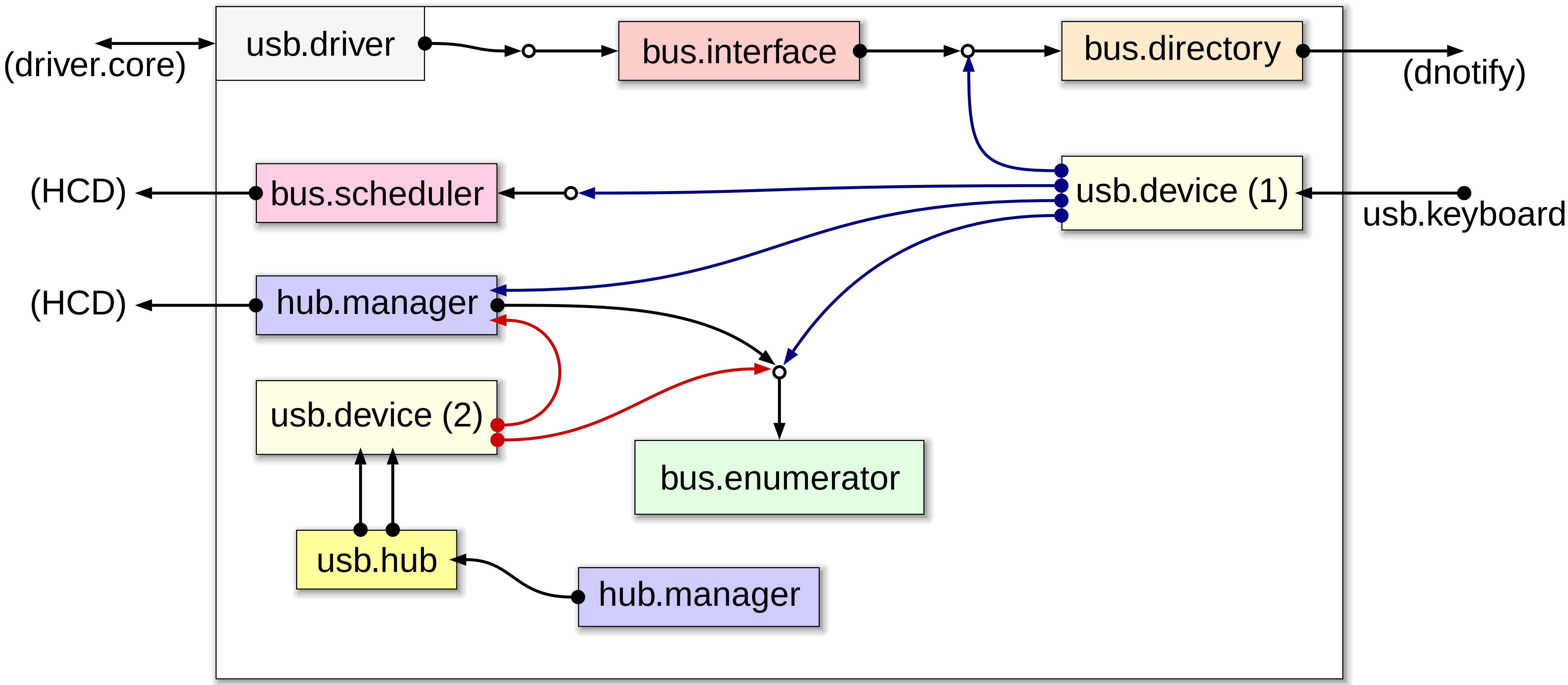

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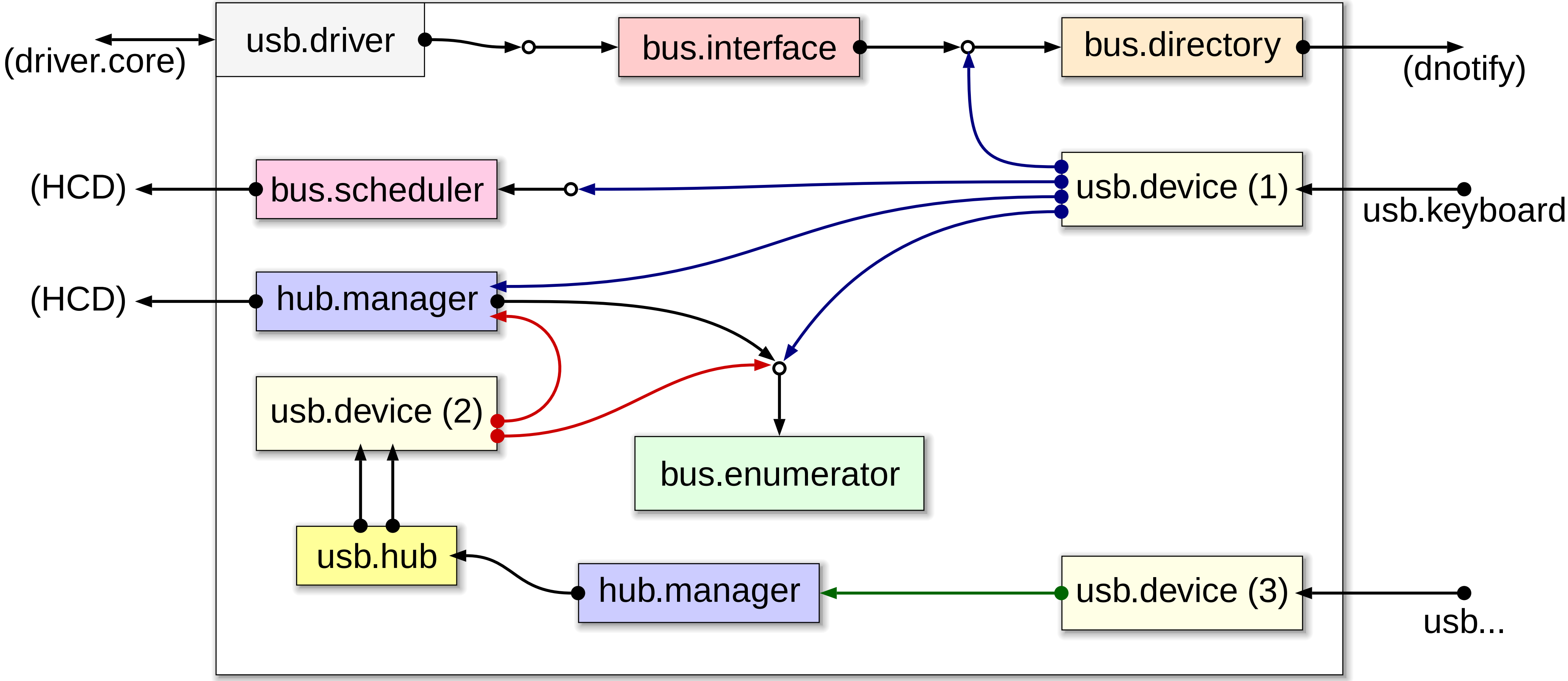

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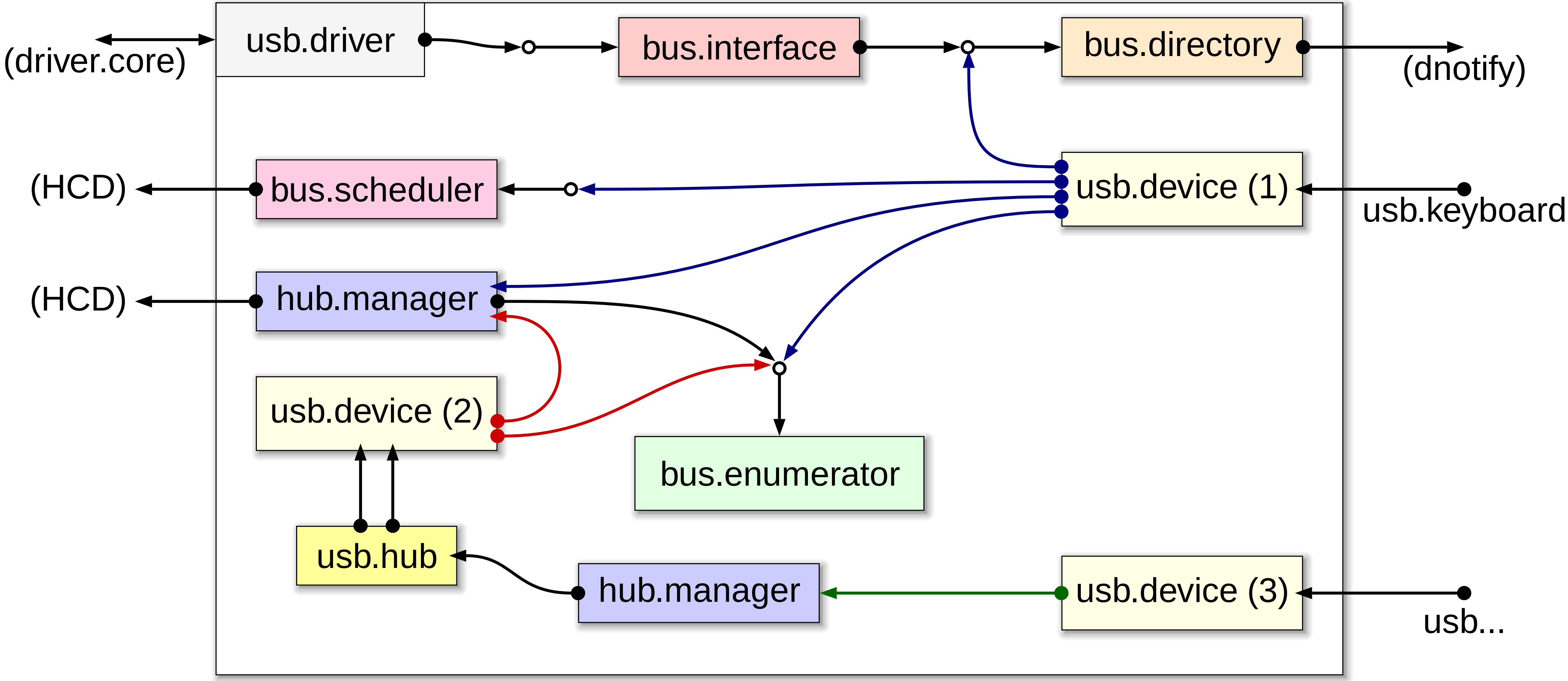

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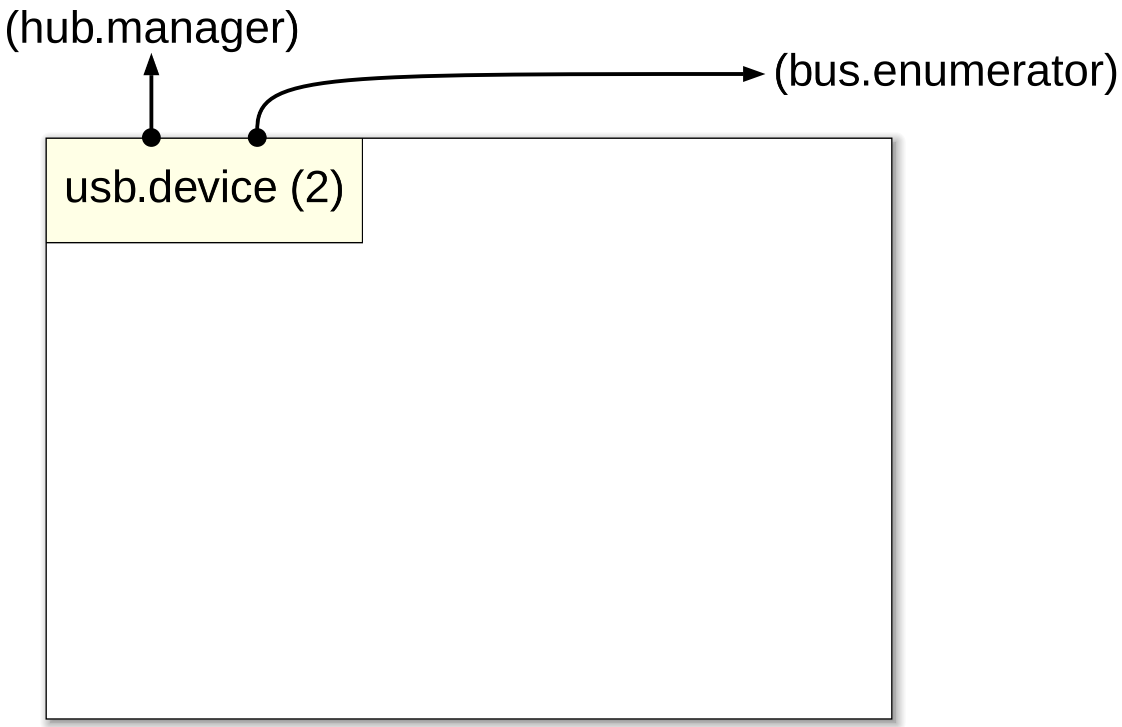

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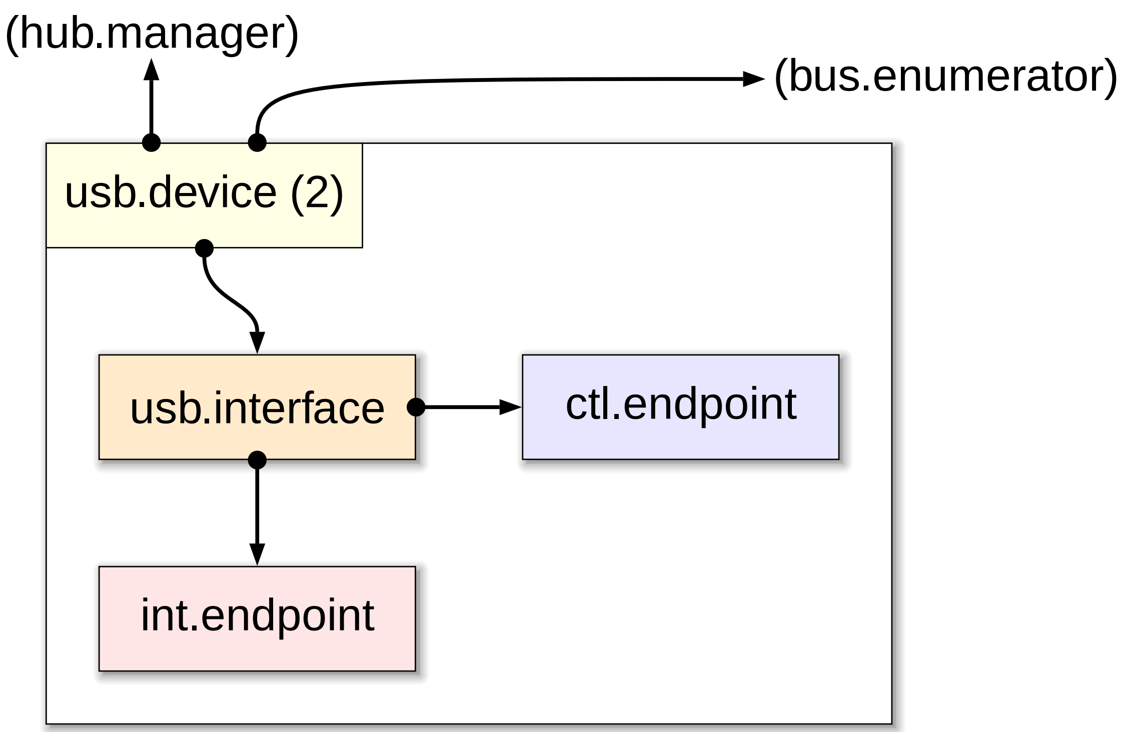

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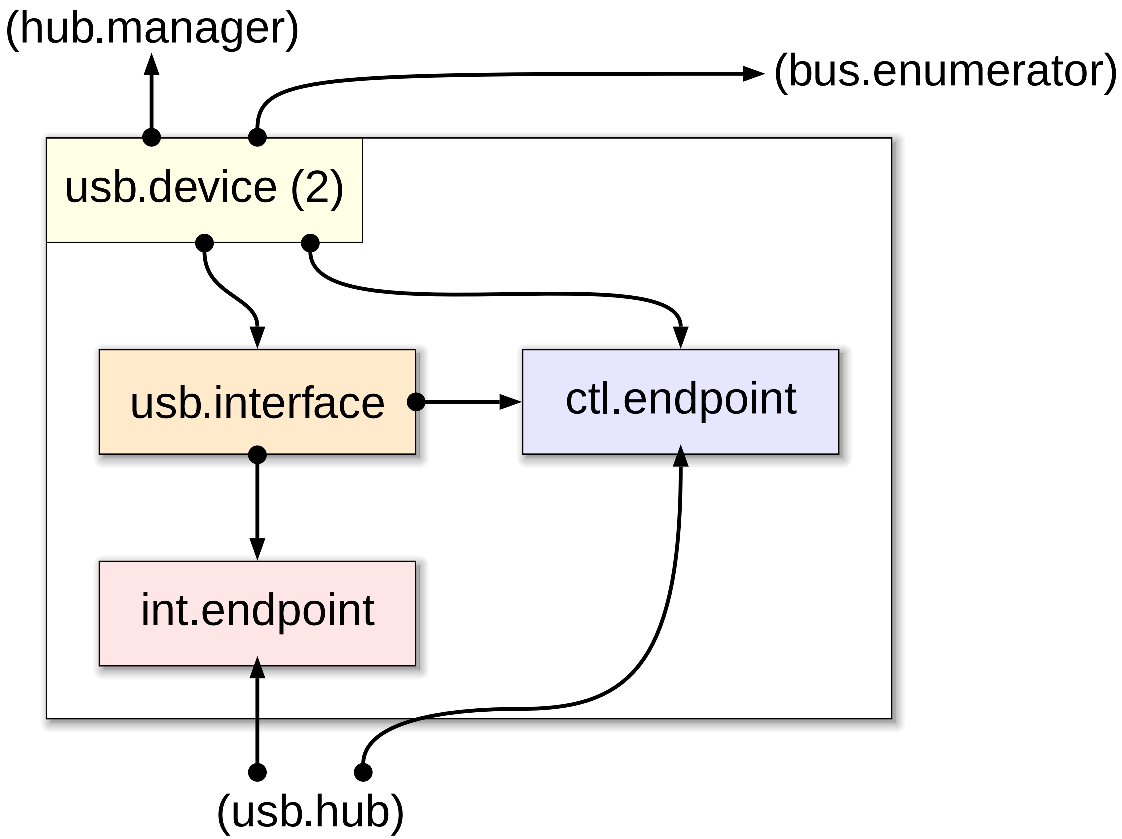

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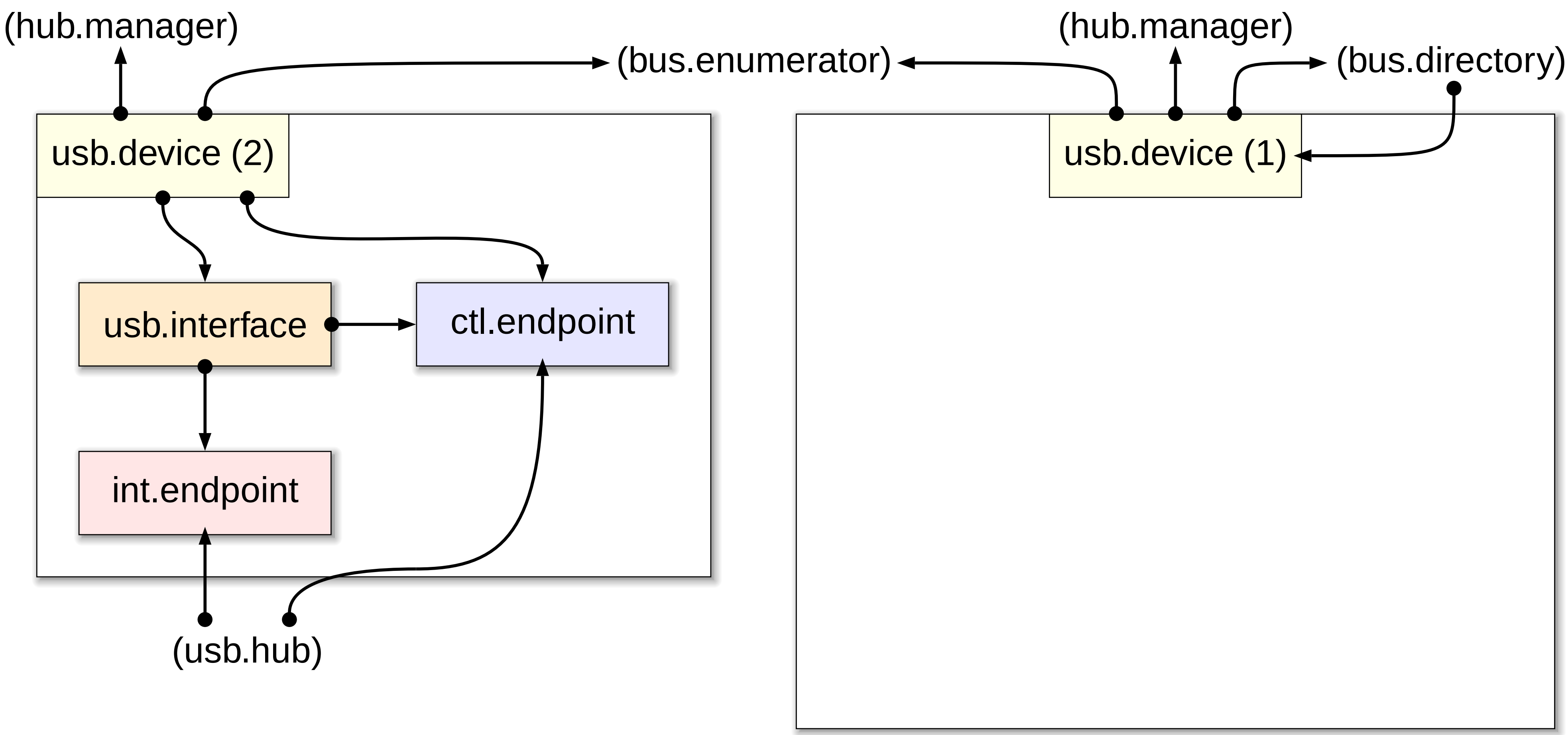

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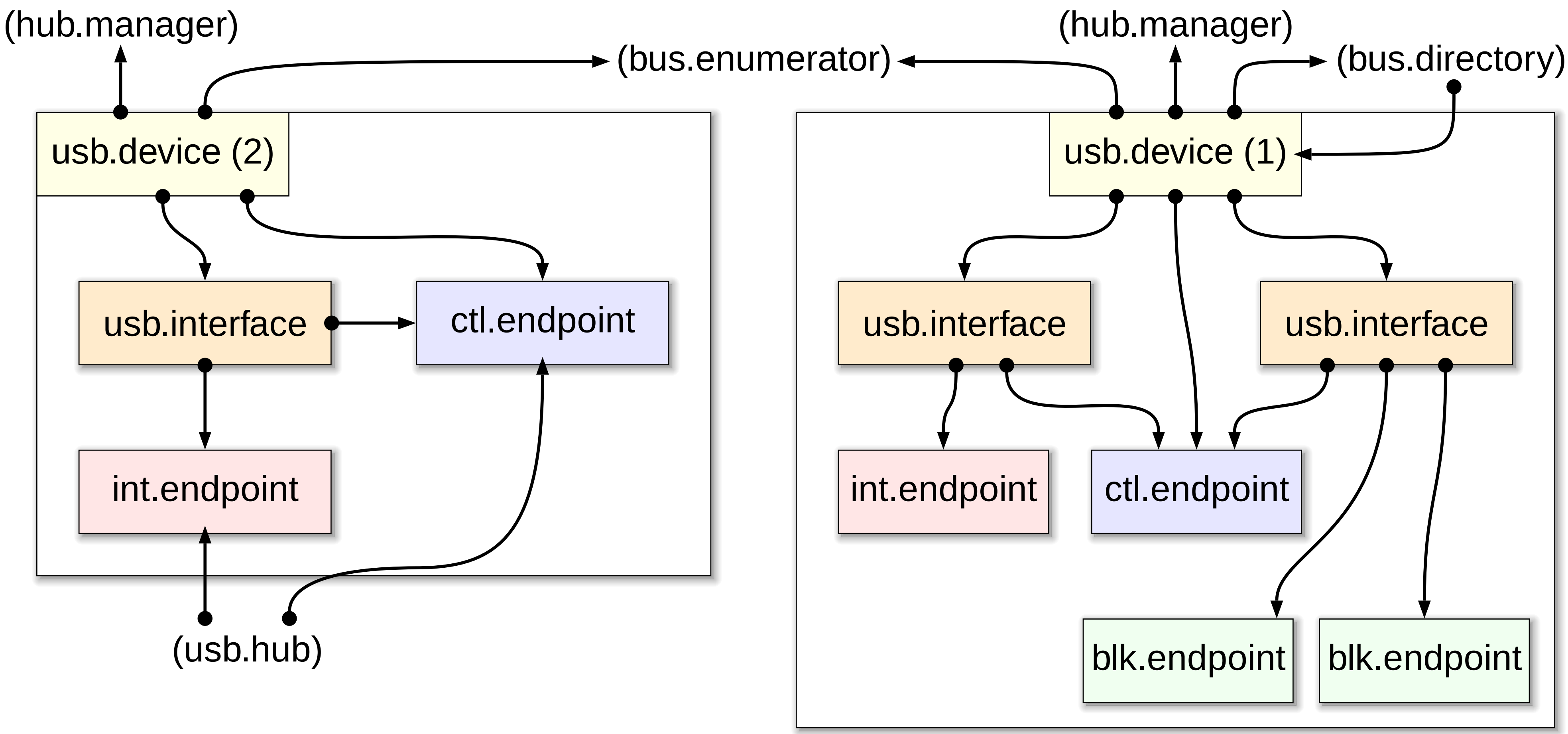

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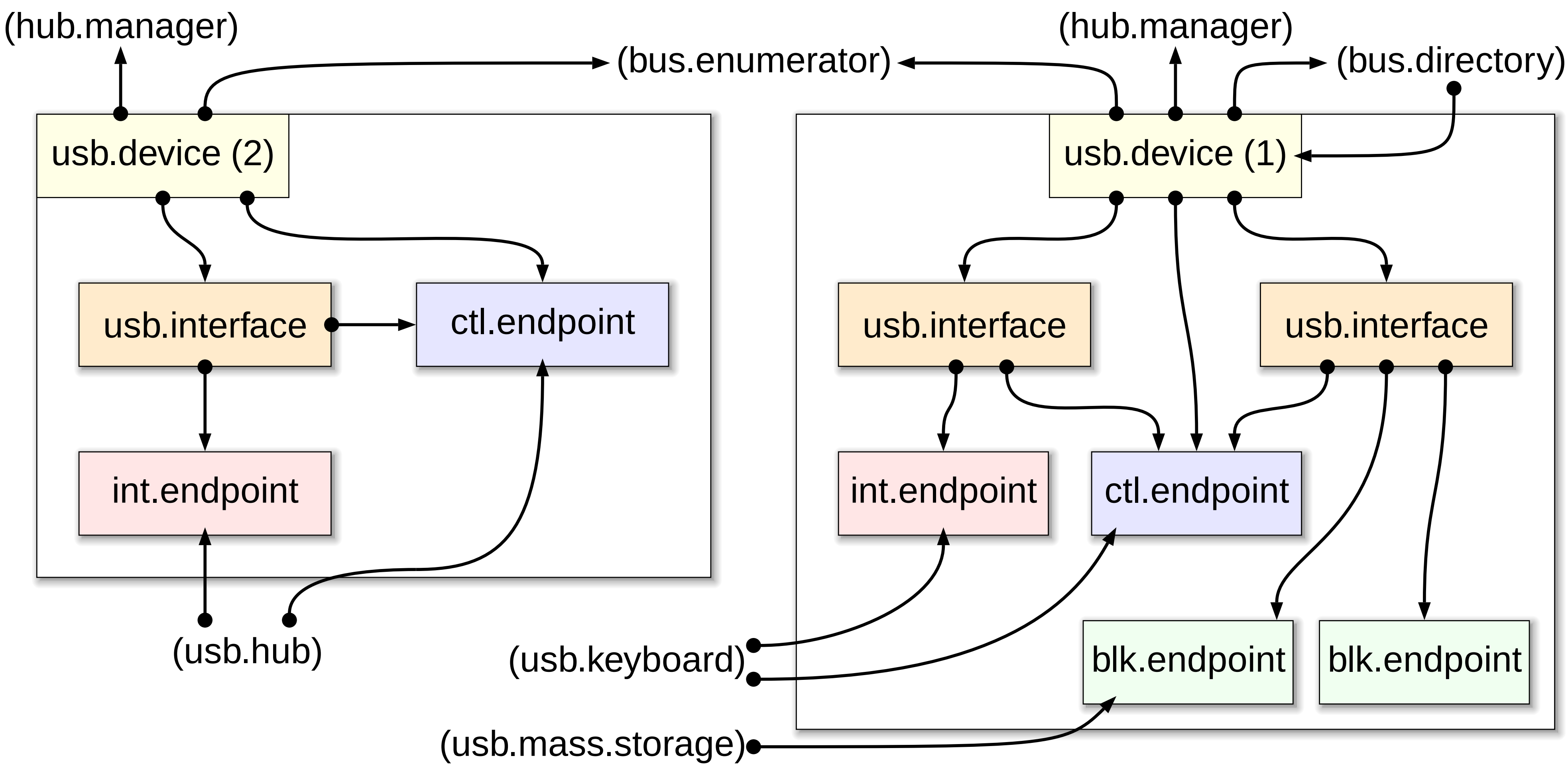

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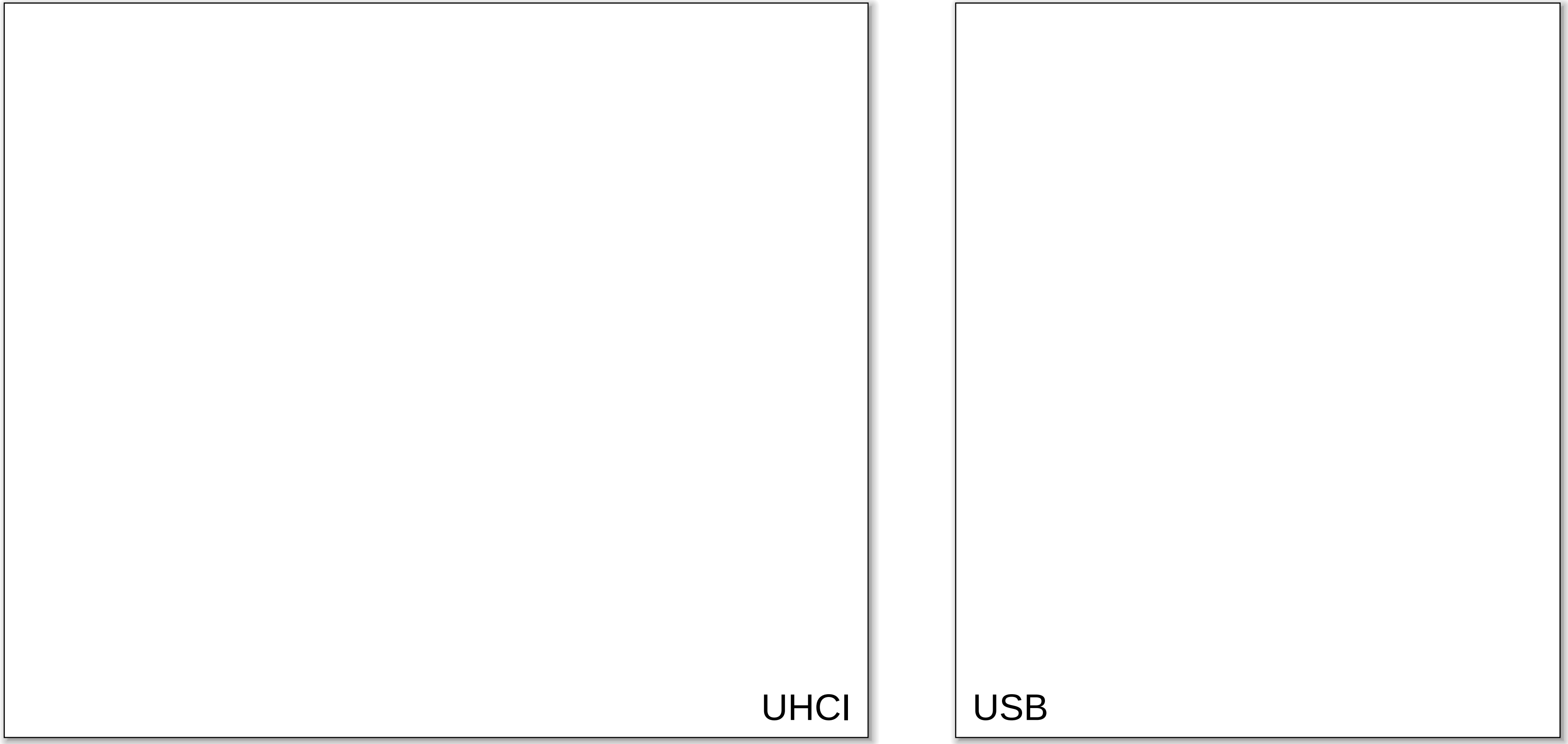

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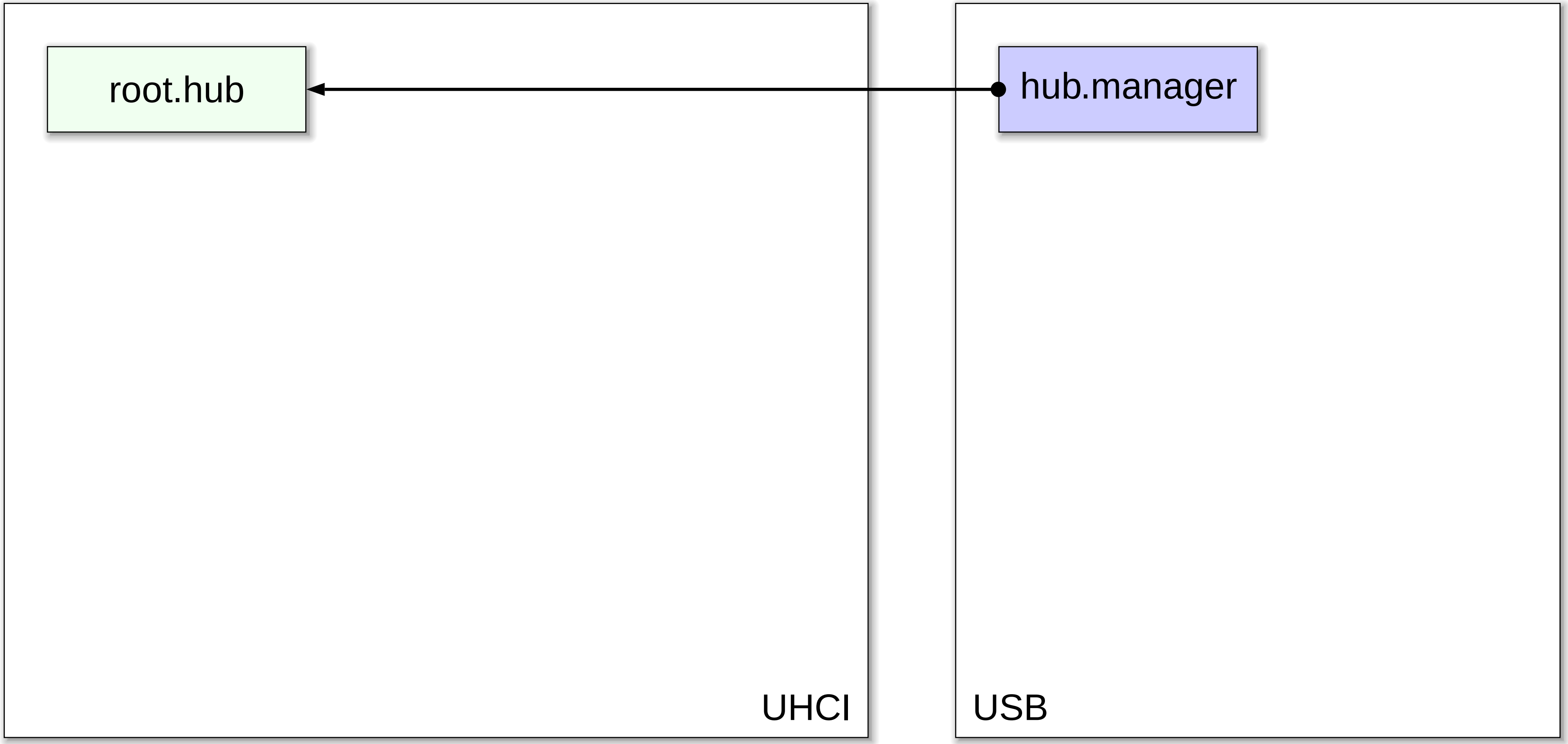

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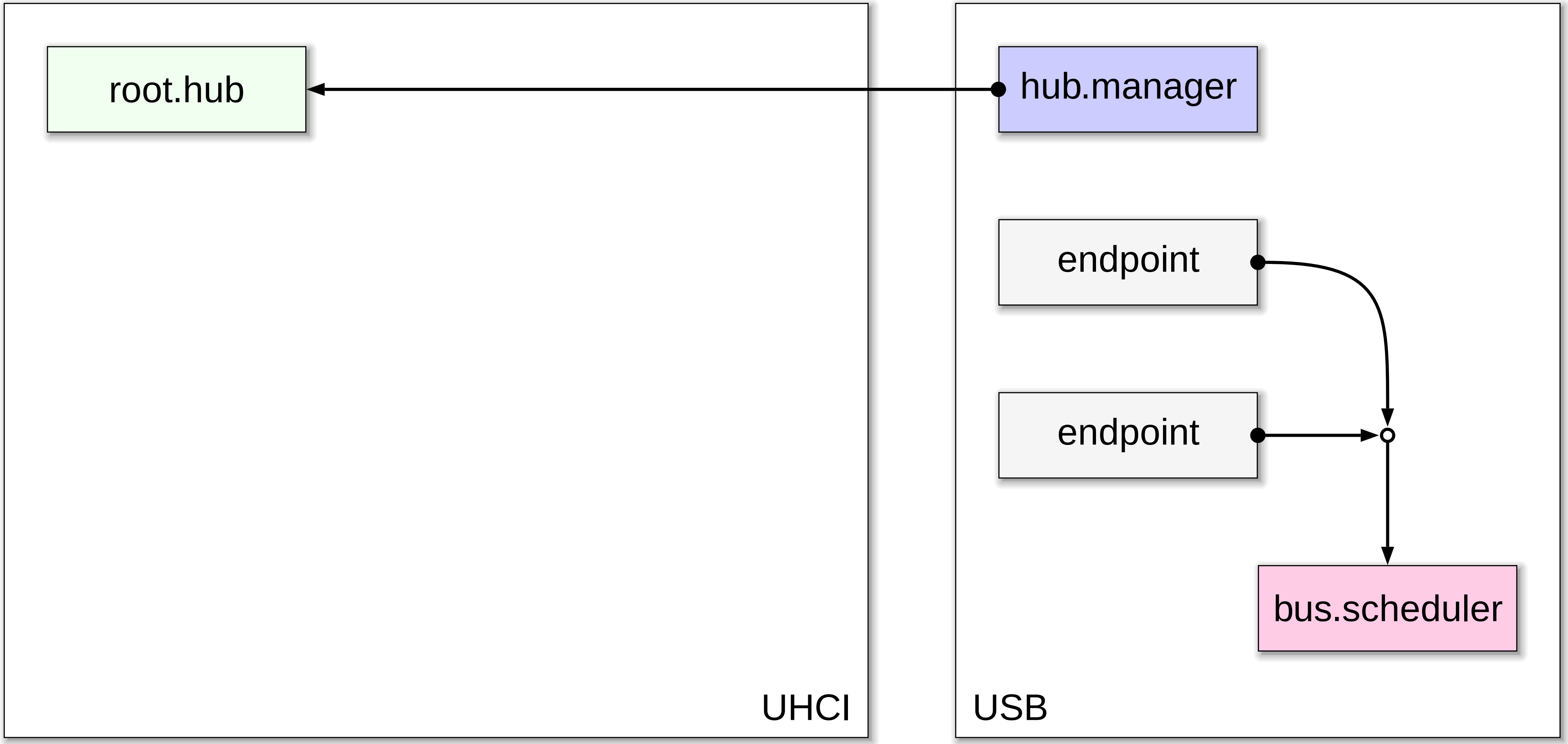

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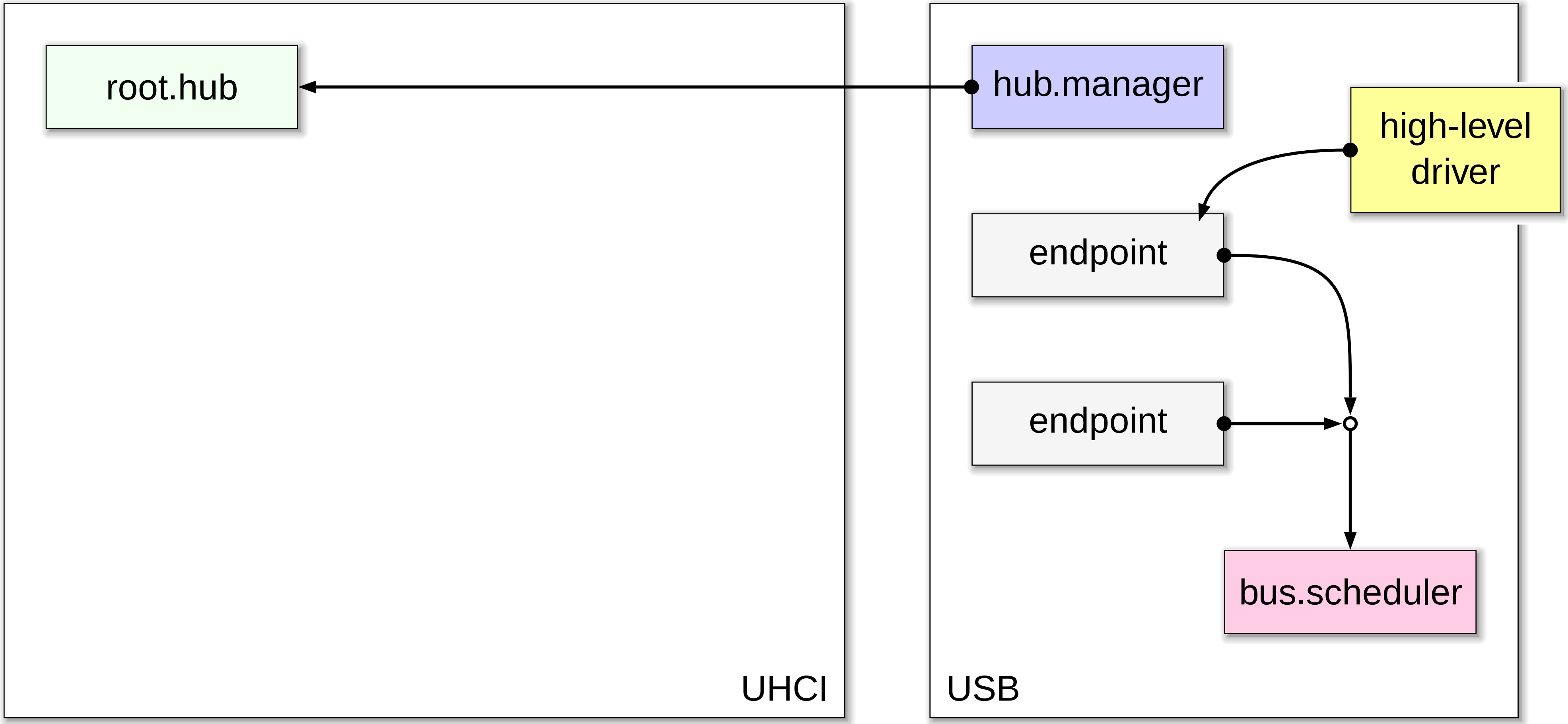

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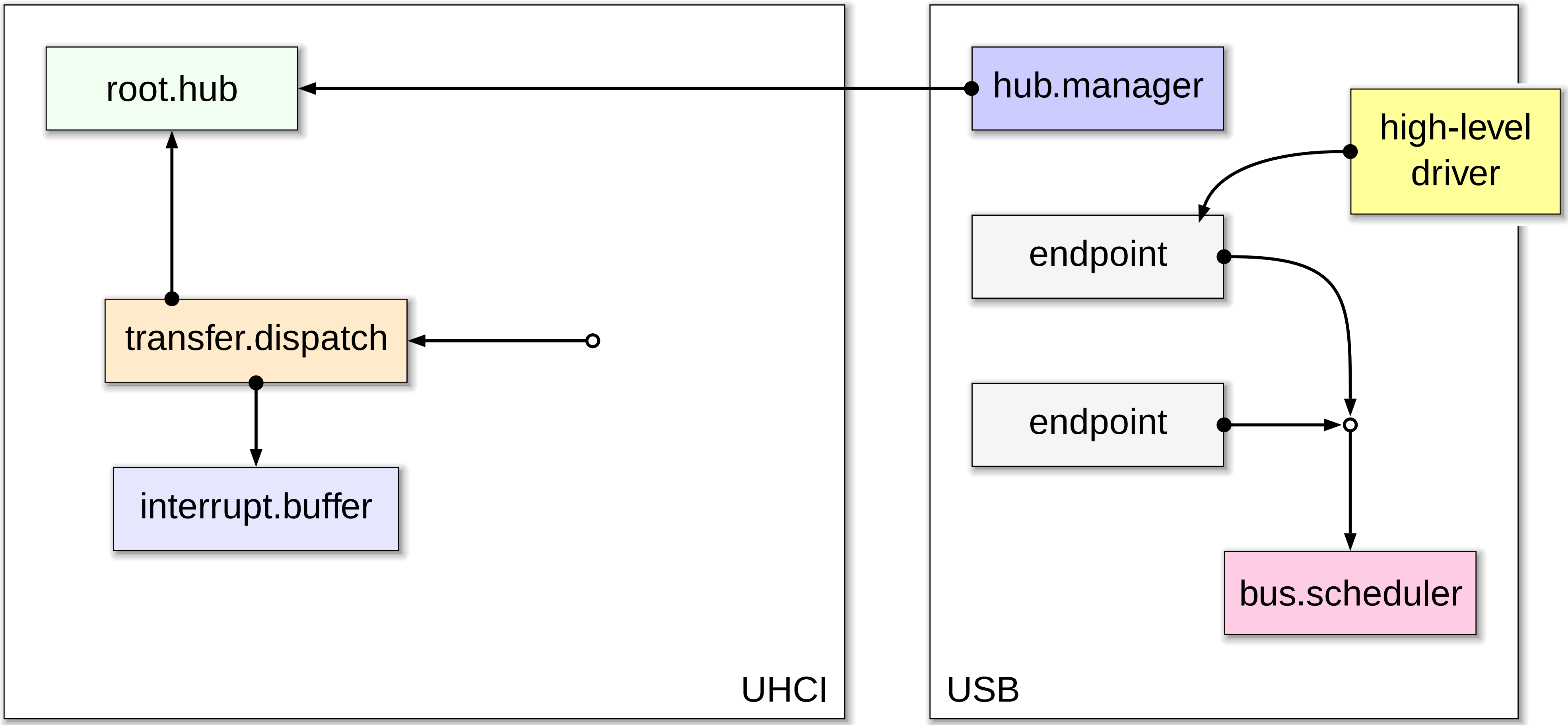

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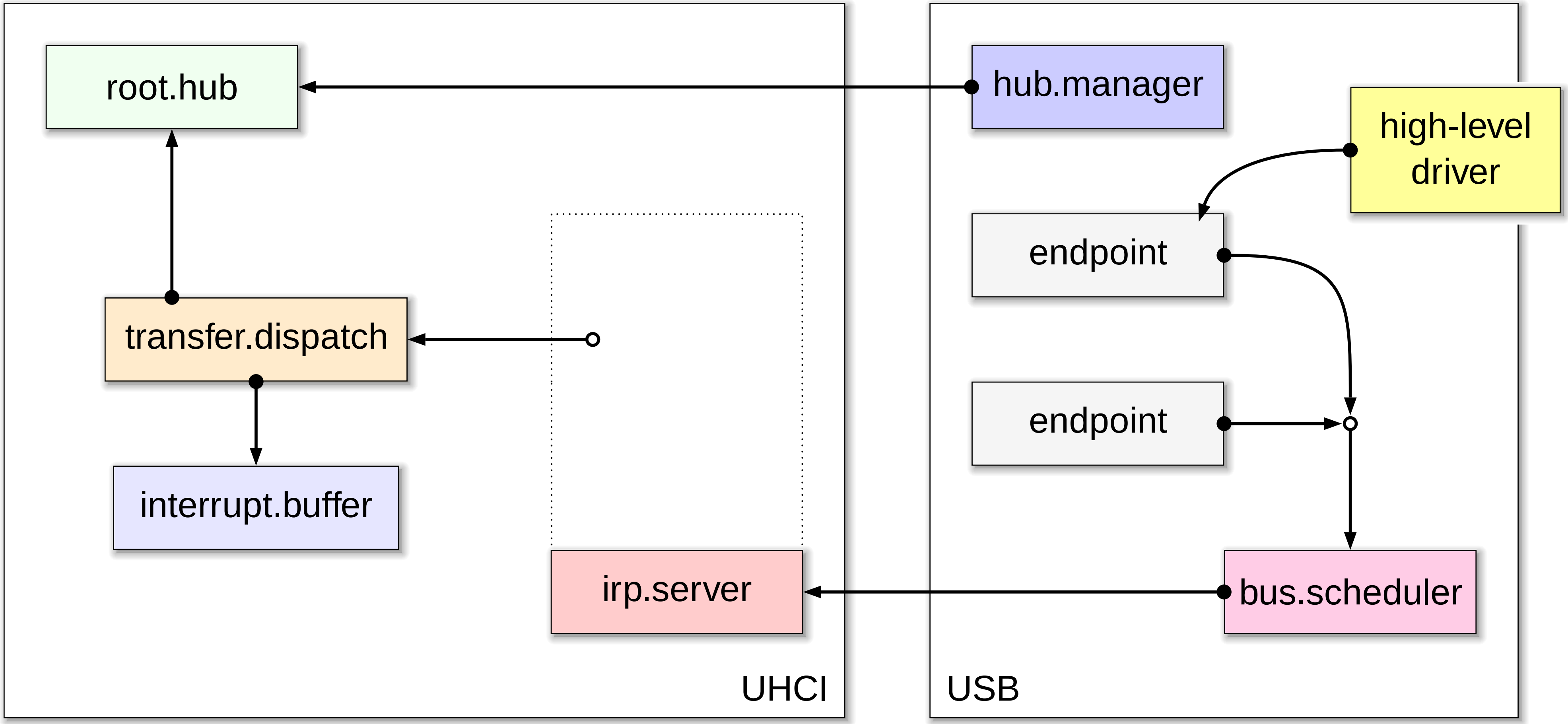

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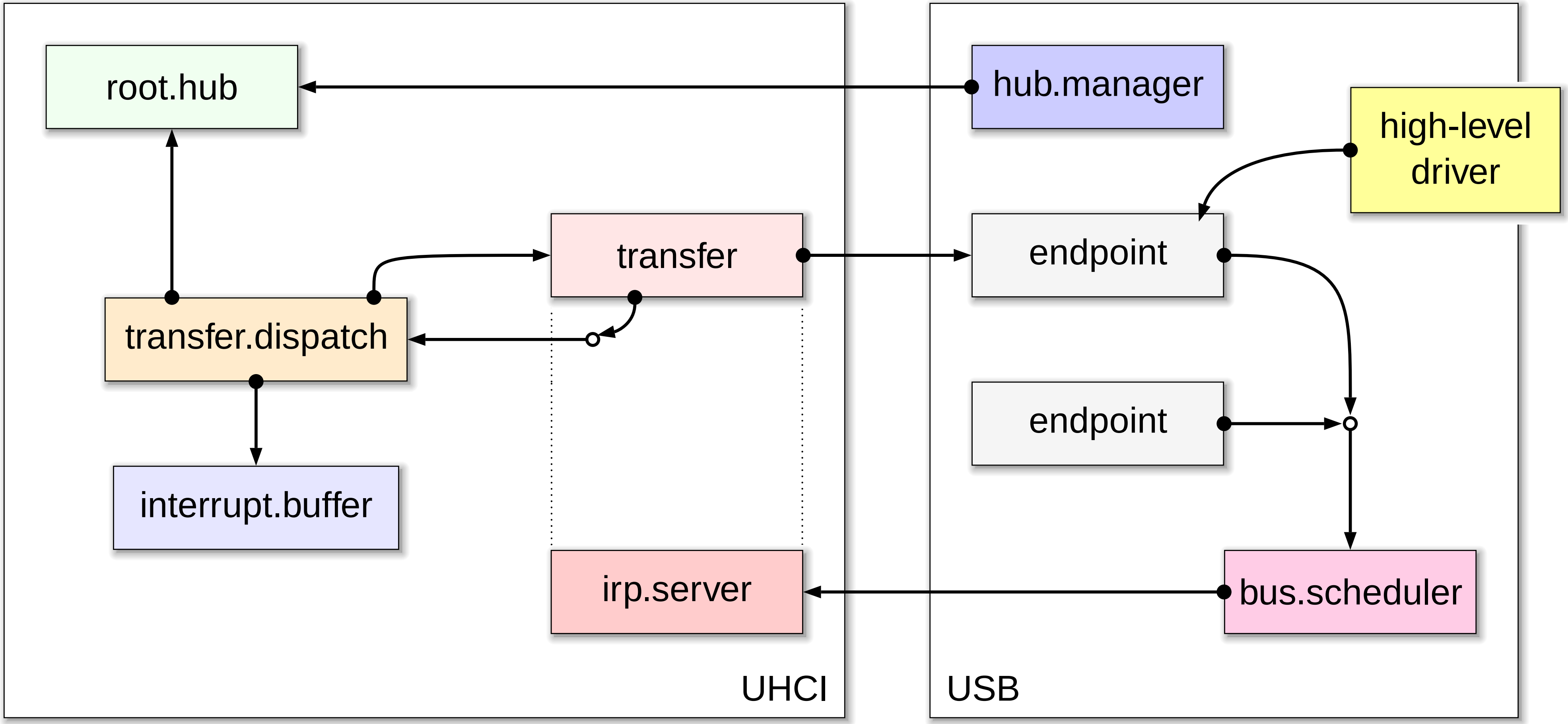

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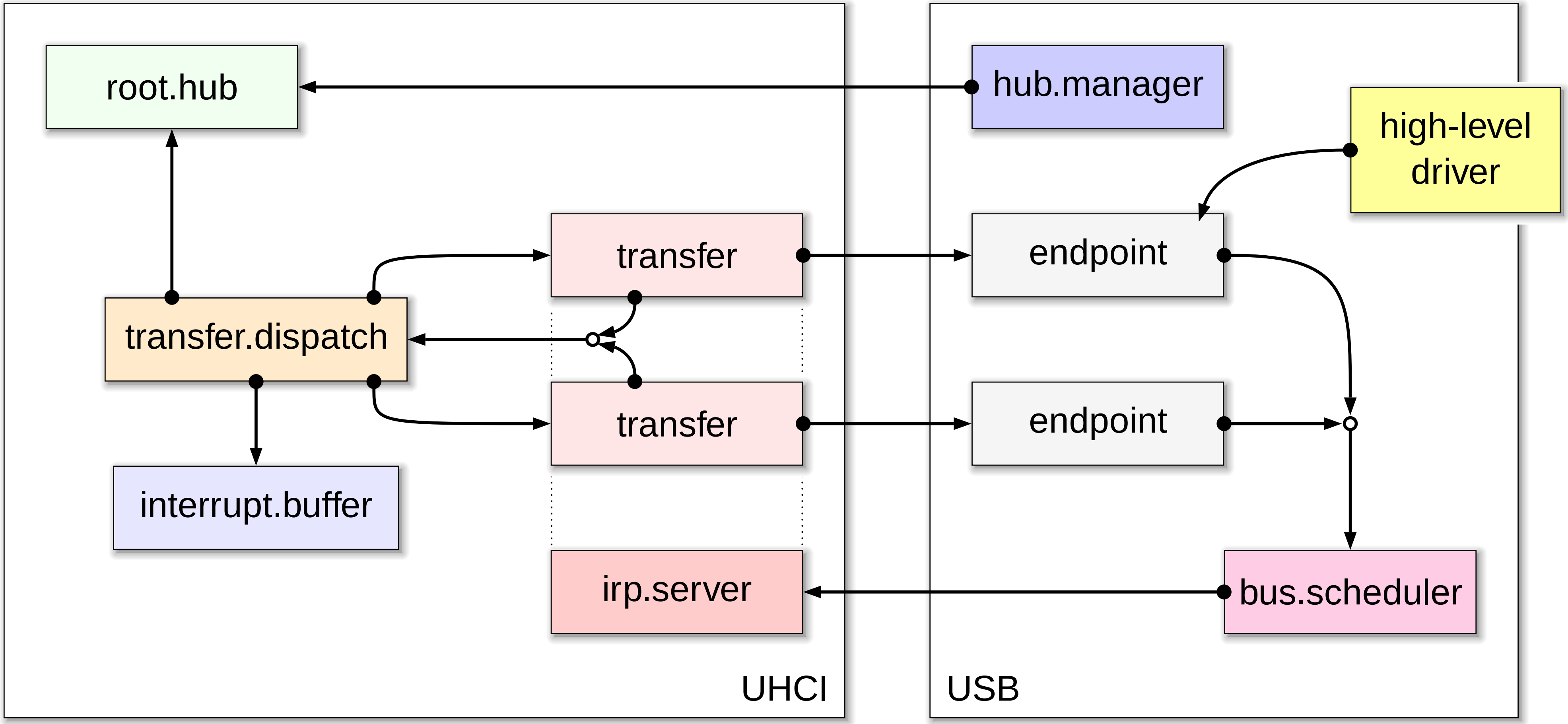

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- Some care required in shut-down when a device is unplugged
  - dummy processes **forked** to service requests, preventing deadlock

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- Questions?