Exploiting USB/IP in Linux

Ignat Korchagin

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@secumod

Who am I?

- systems engineer at Cloudflare
- interests in security and crypto
- enjoy low-level programming
- more builder than a breaker
- … but try to stay alert

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Agenda

- What is USB/IP
- USB/IP implementation in Linux
- Overview of sharing a USB device
- Vulnerable USB/IP code
- Potential exploit impact
- Hardening USB/IP setups


black hat
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But first....

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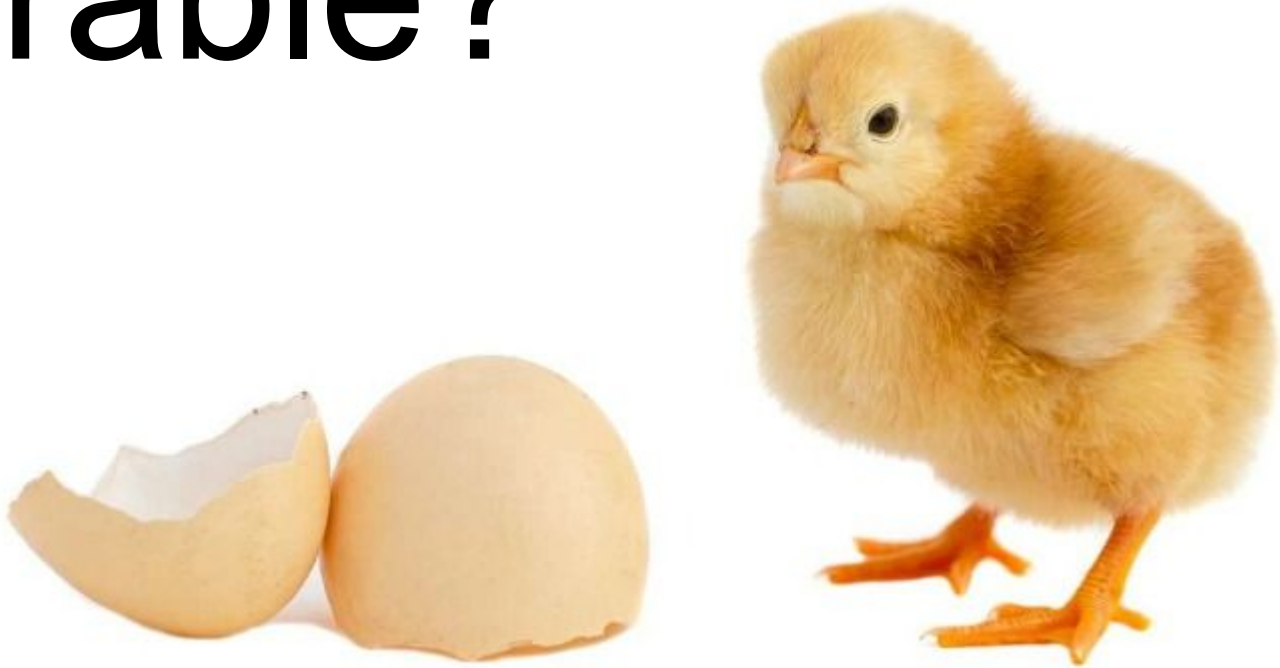
Am I vulnerable?



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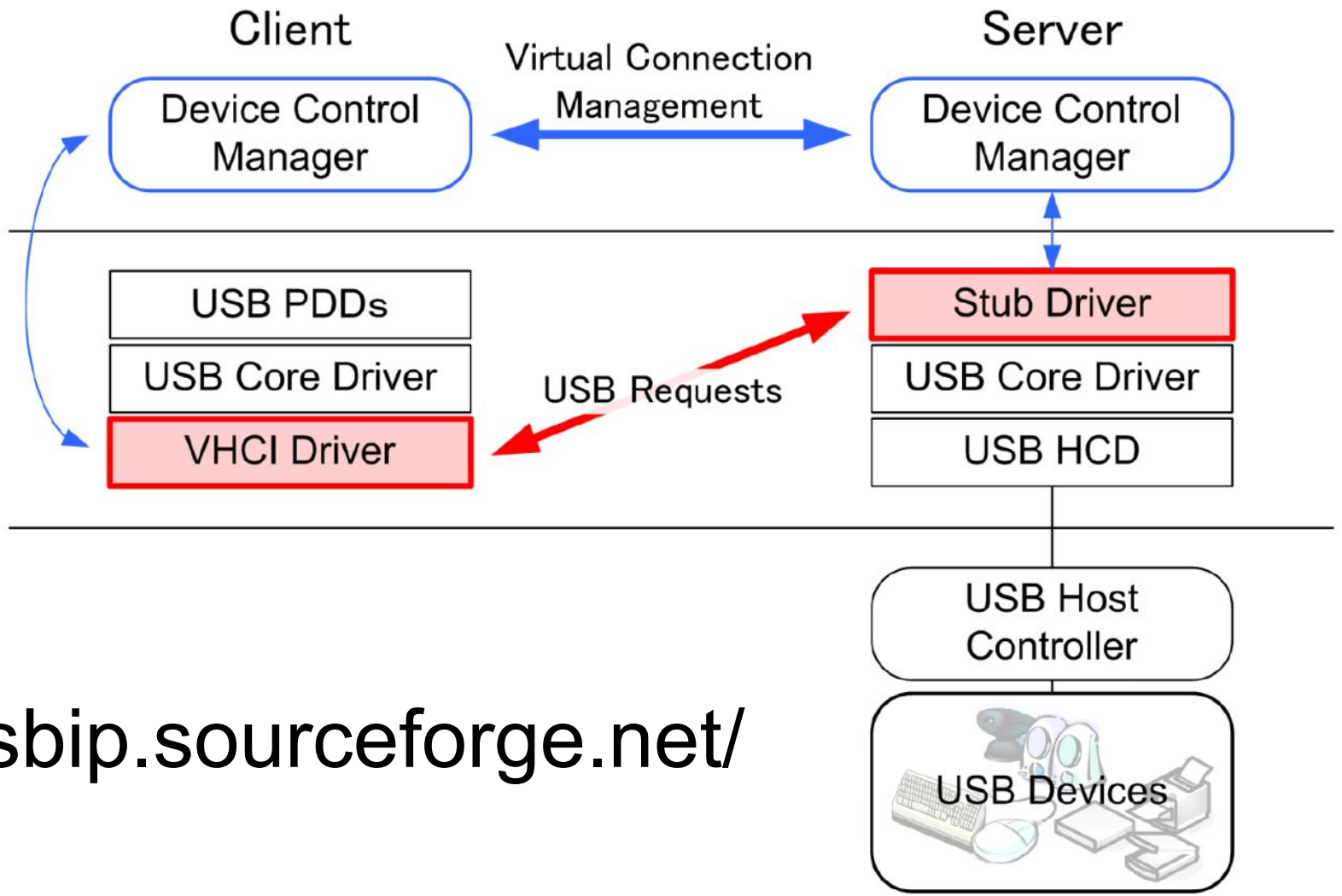
- driver/device agnostic
- sends URBs over TCP connection
- implemented for Linux and Windows

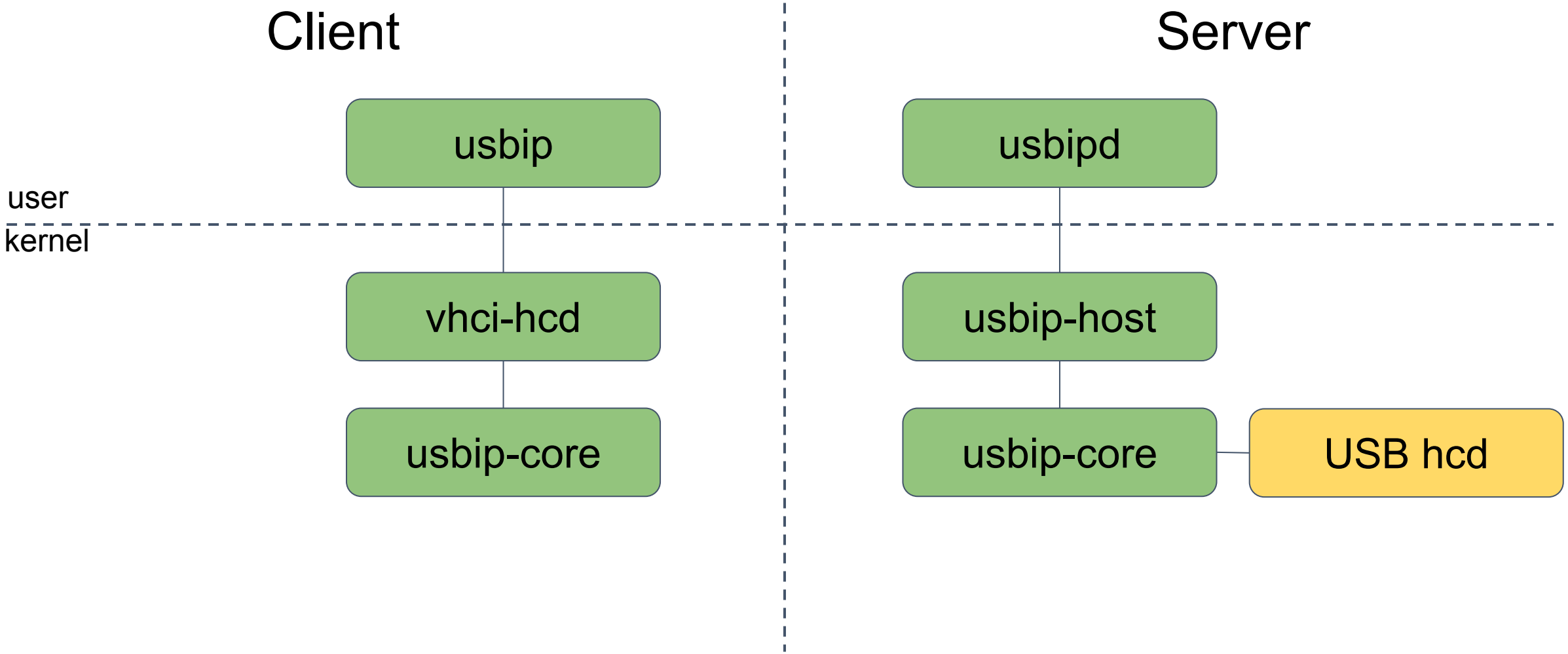
USB/IP architecture



http://usbip.sourceforge.net/

USB/IP implementation in Linux

USB/IP Linux implementation



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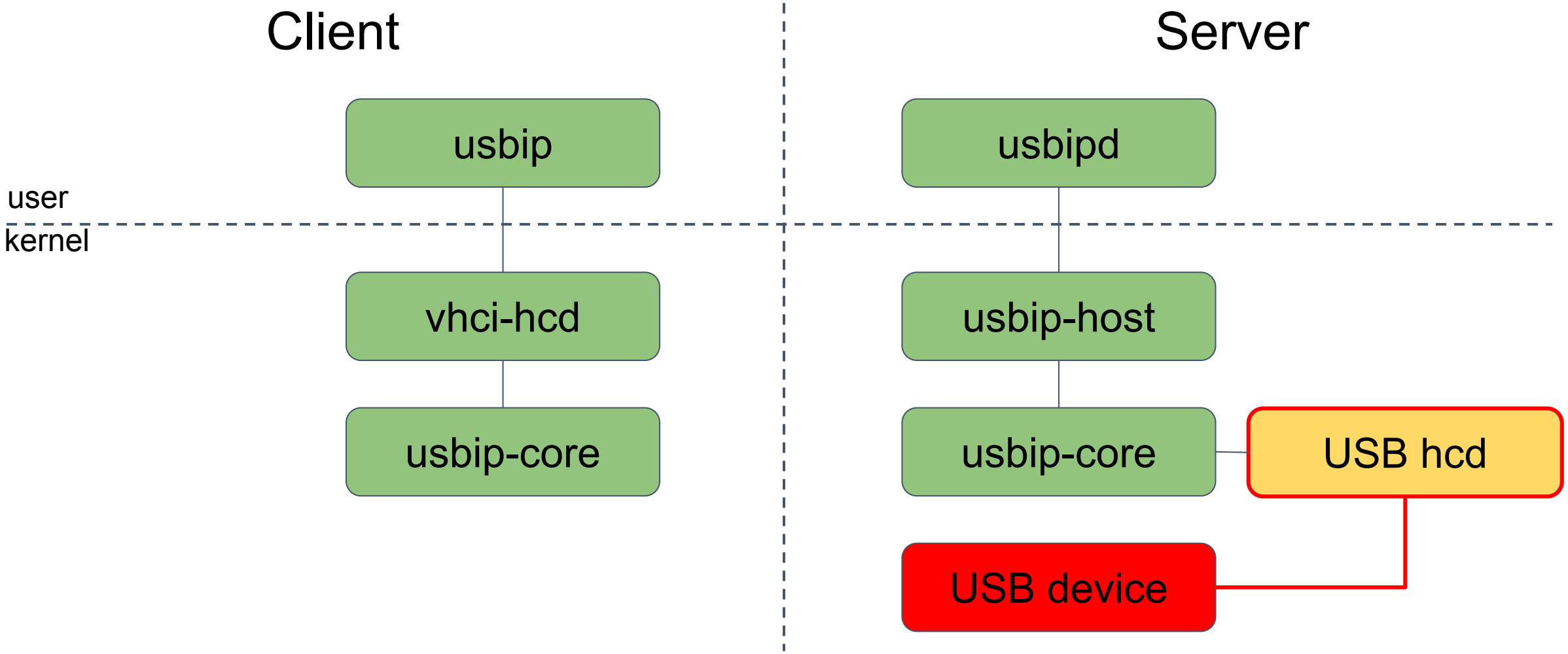

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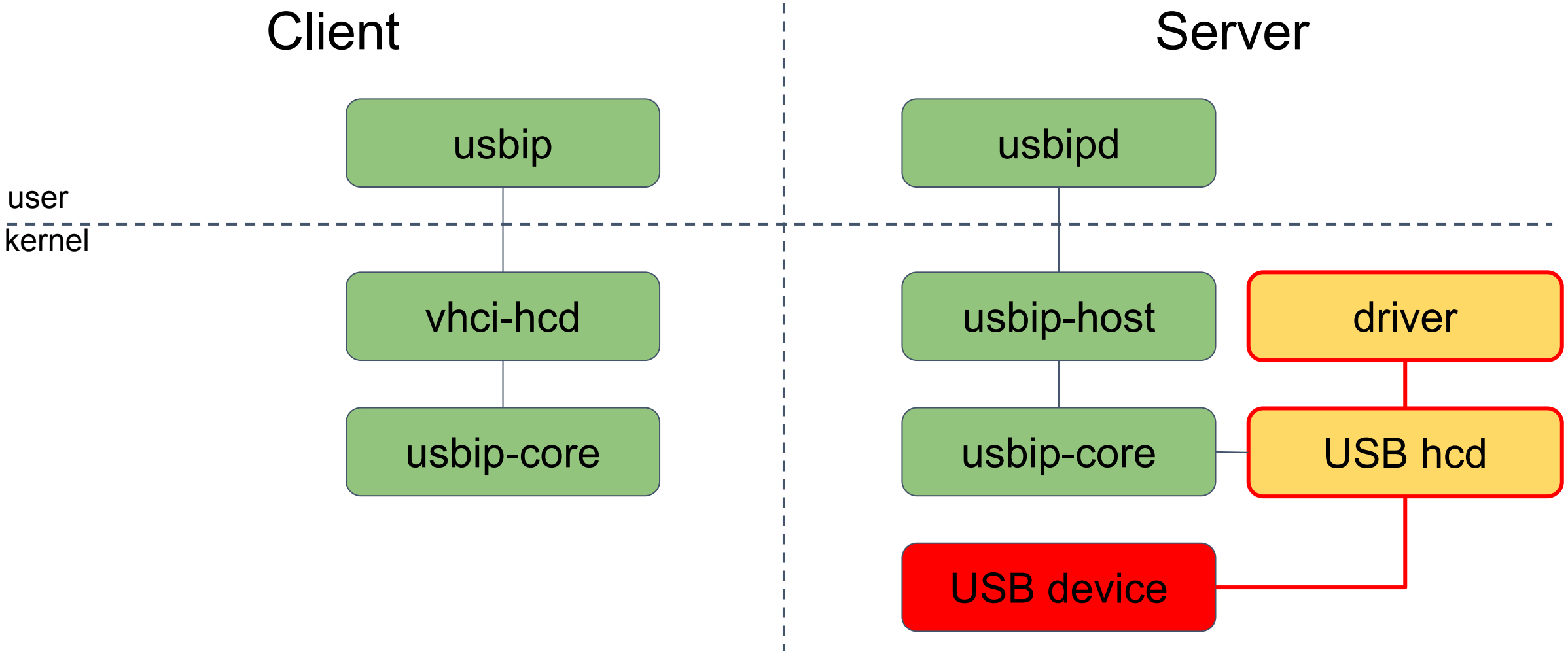

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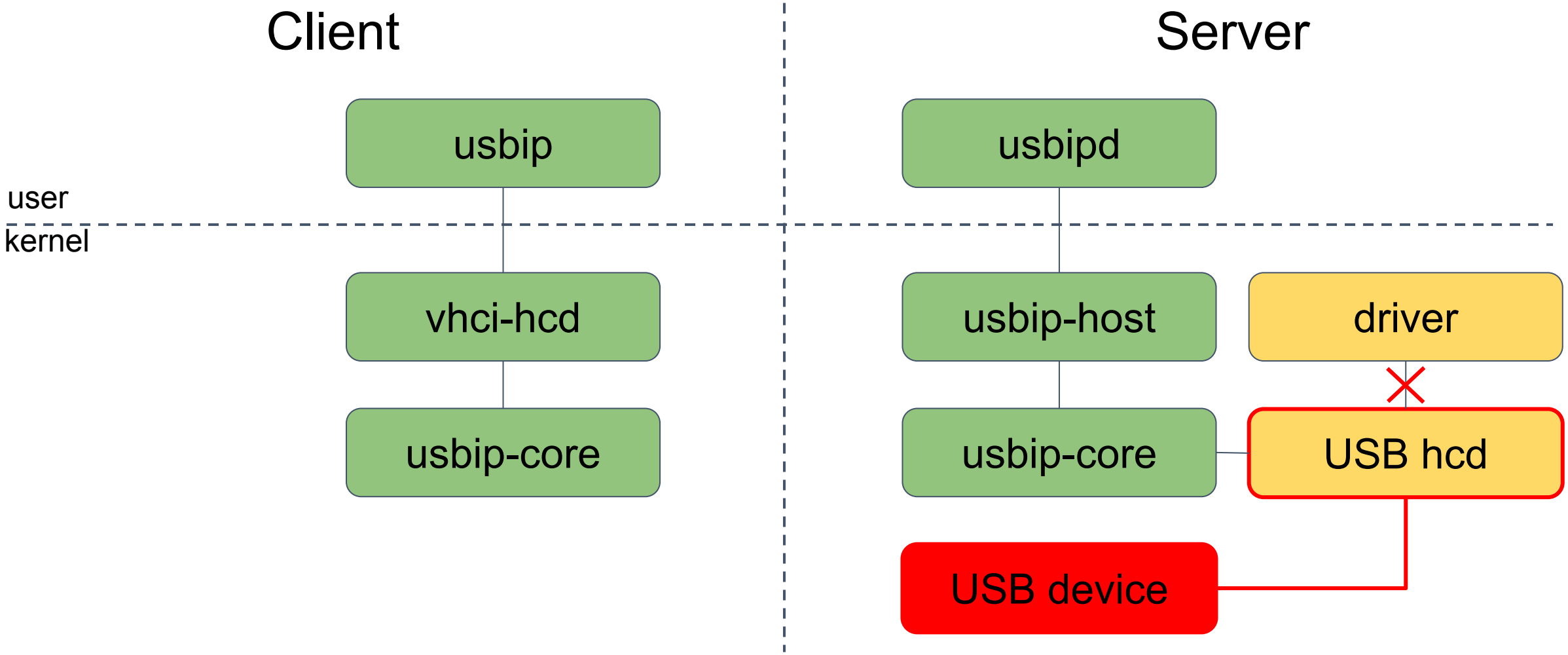

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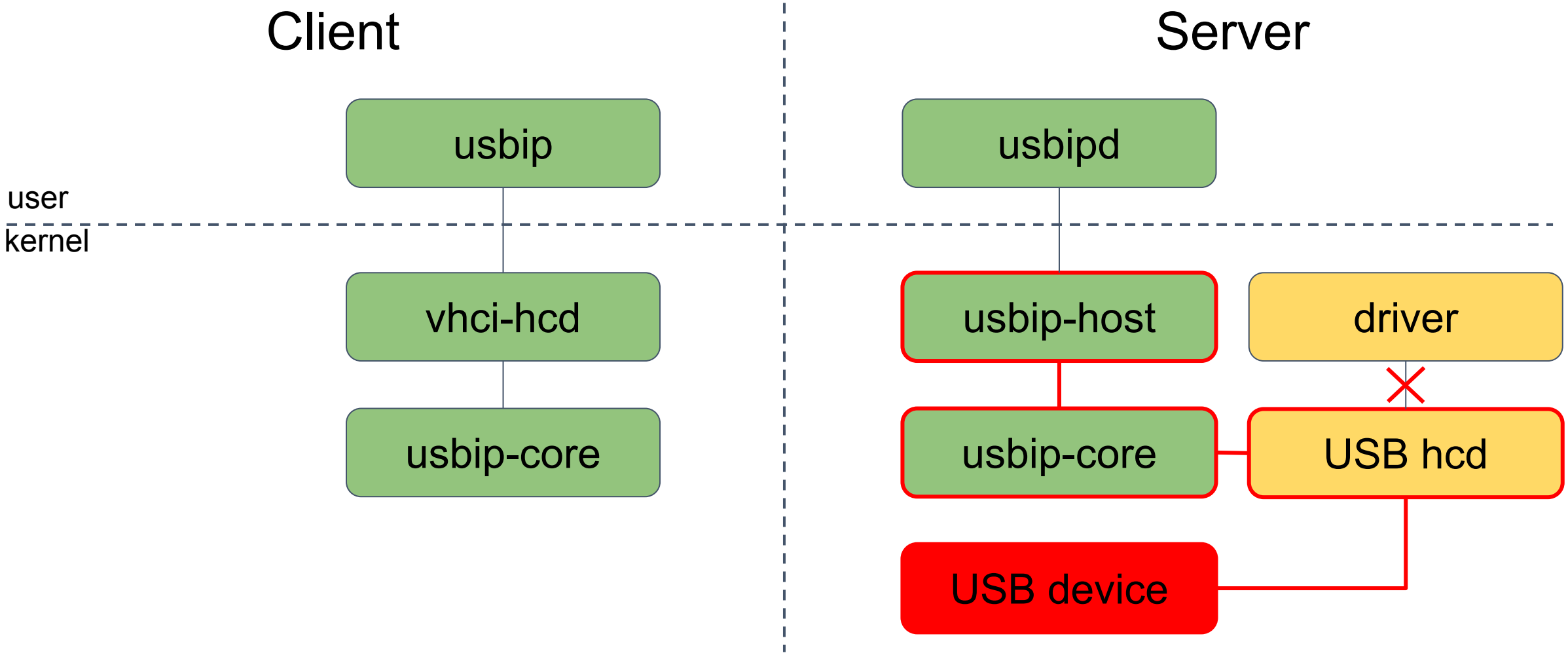

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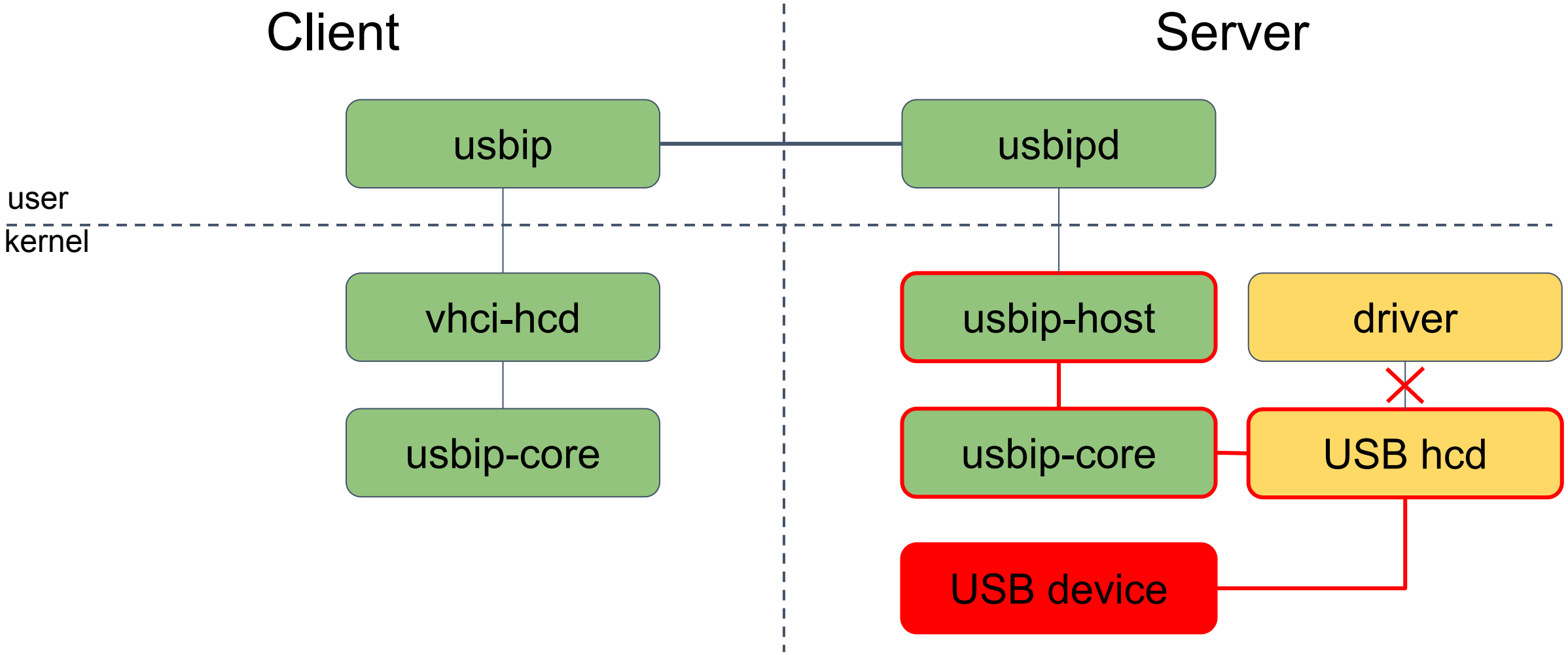

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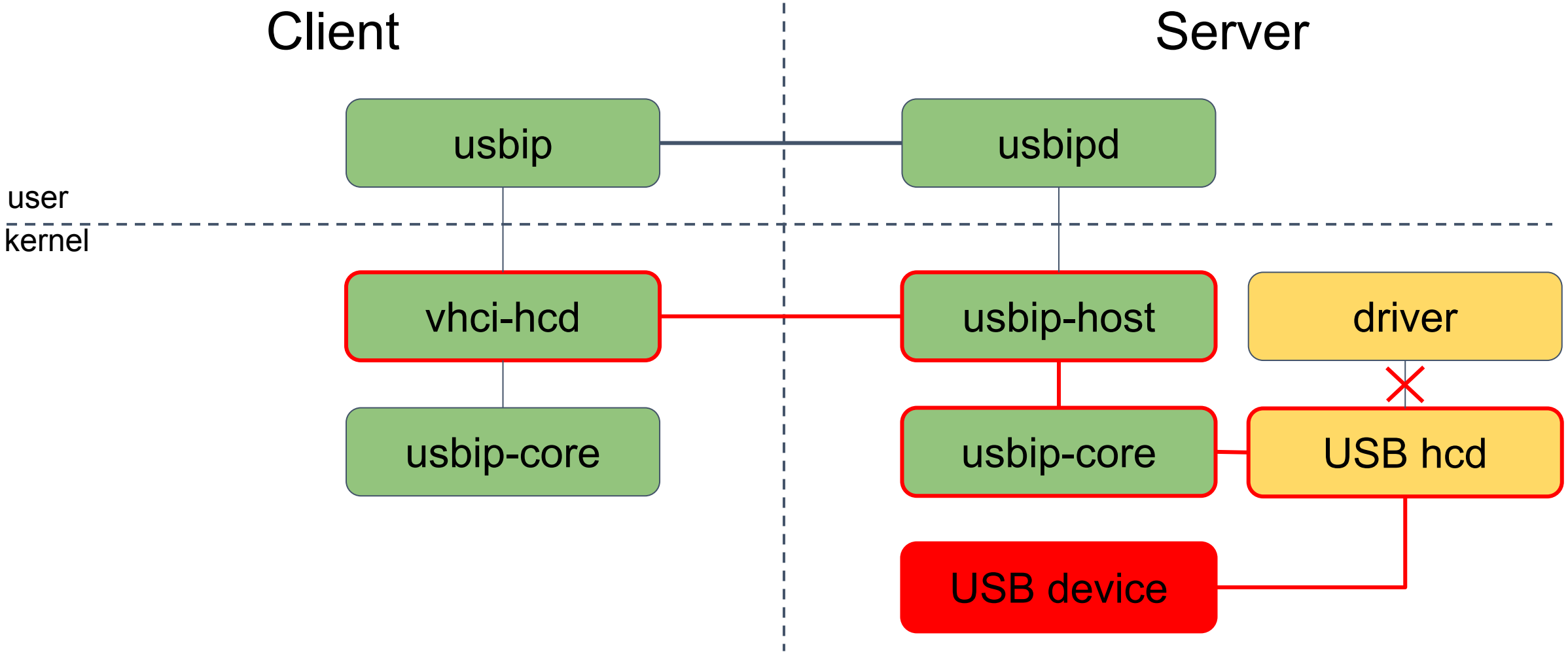

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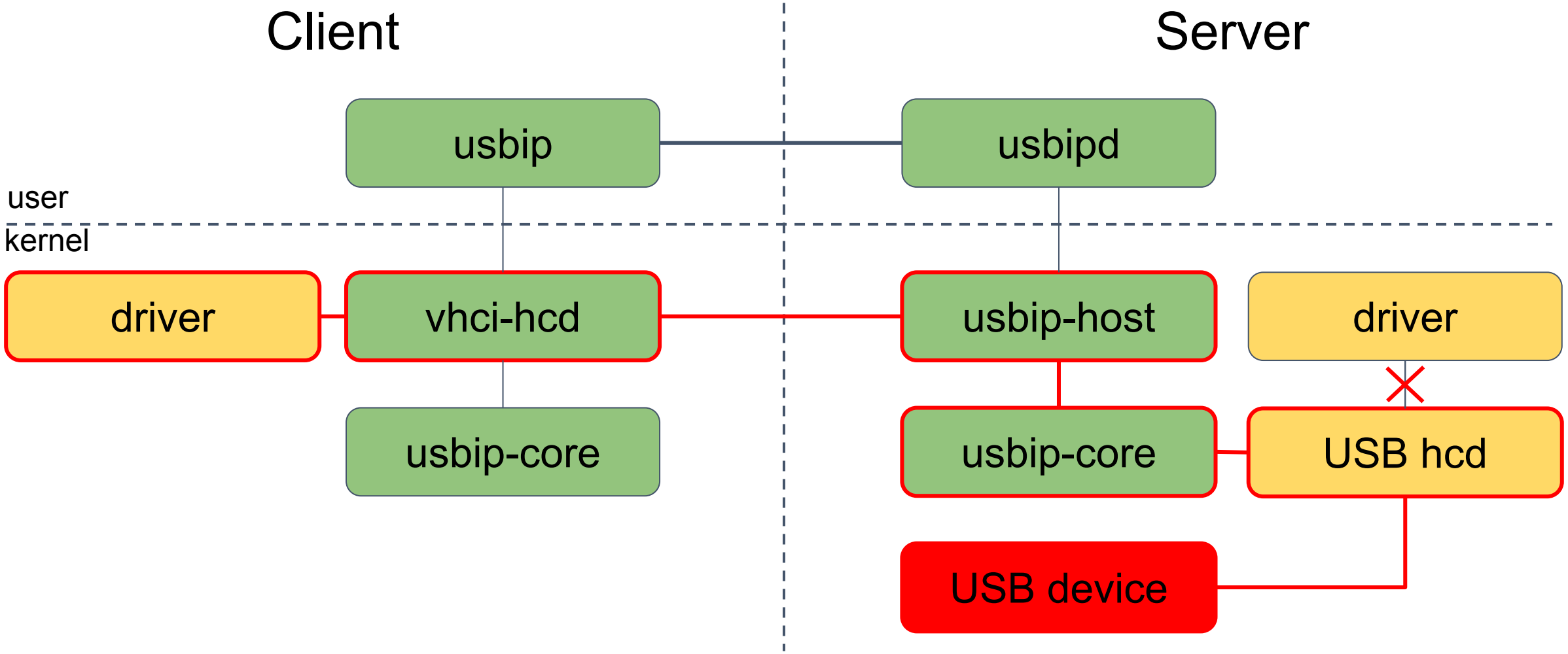

USB/IP Linux implementation

```
$ usbip list -r 127.0.0.1
usbip: error: failed to open /usr/share/hwdata//usb.ids
Exportable USB devices
======================
 - 127.0.0.1
        1-1: unknown vendor : unknown product
(dead:beef)
           : /sys/fake/dangerous/usbipdemo
           : (Defined at Interface level) (00/00/00)
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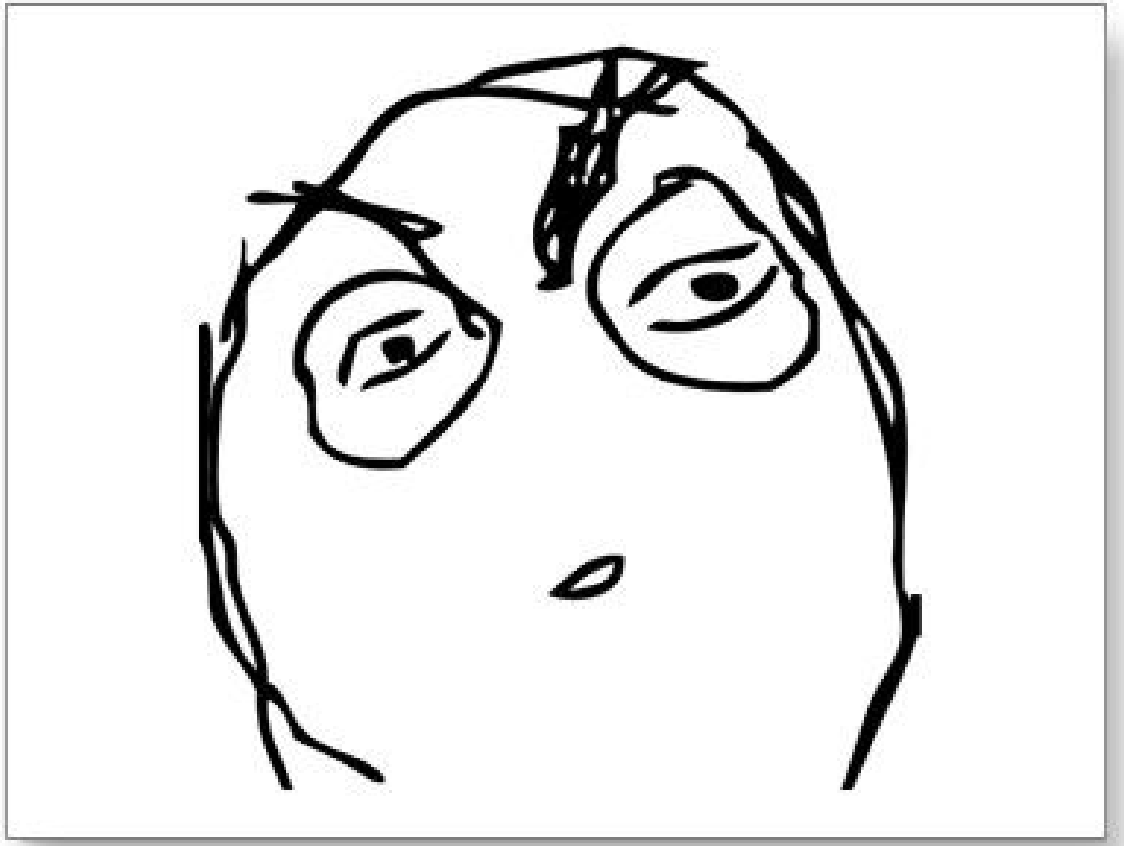
$ sudo usbip attach -r 127.0.0.1 -b 1-1
```

USB/IP Linux implementation

```
$ ps aux | grep usbip
root       884  0.0  0.0      0     0 ?        S    16:46   0:00 [usbip_eh]
root       886  0.0  0.0      0     0 ?        S    16:46   0:00 [usbip_eh]
root       887  0.0  0.0      0     0 ?        S    16:46   0:00 [usbip_eh]
root       888  0.0  0.0      0     0 ?        S    16:46   0:00 [usbip_eh]
root       889  0.0  0.0      0     0 ?        S    16:46   0:00 [usbip_eh]
root       890  0.0  0.0      0     0 ?        S    16:46   0:00 [usbip_eh]
root       891  0.0  0.0      0     0 ?        S    16:46   0:00 [usbip_eh]
root       892  0.0  0.0      0     0 ?        S    16:46   0:00 [usbip_eh]
ignat      895  0.0  0.0  14228   980 pts/1    S+   16:46   0:00 grep usbip
```

WAT?



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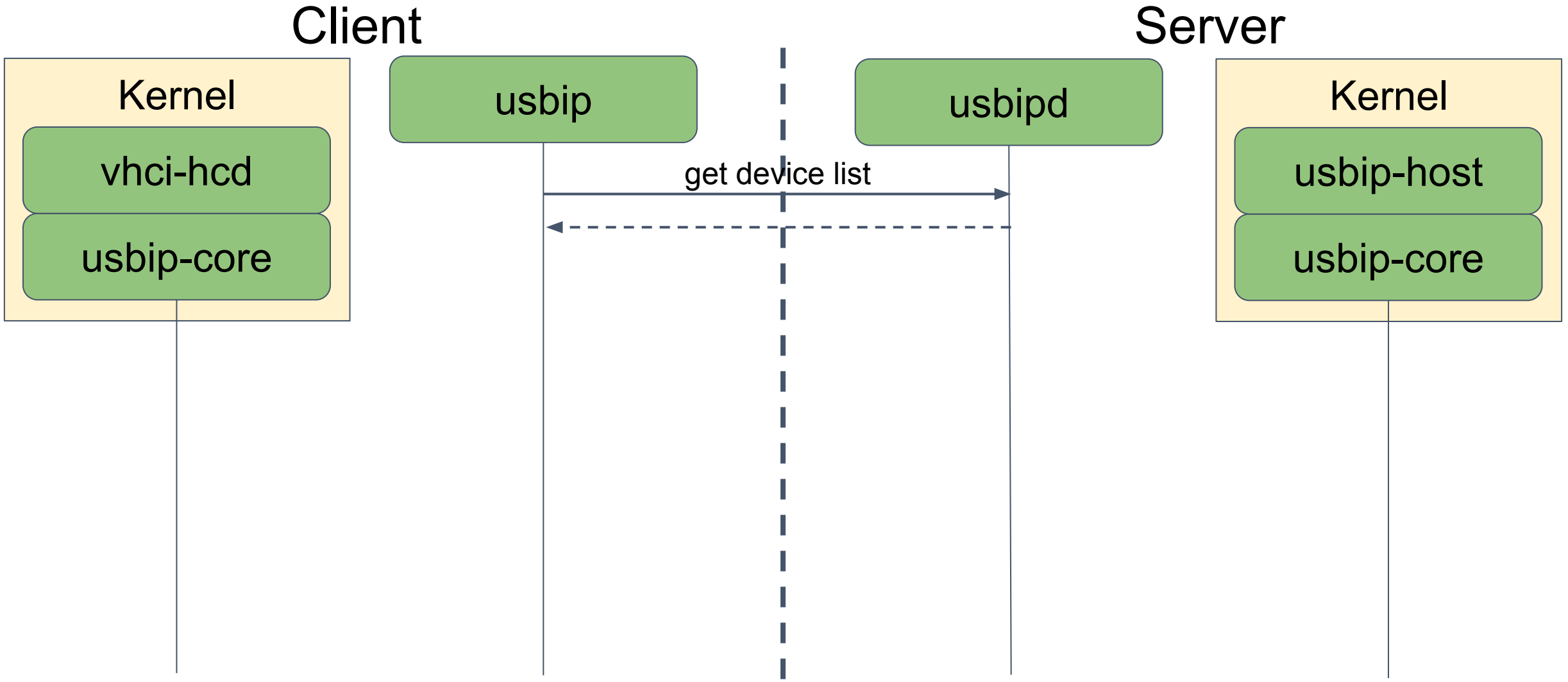

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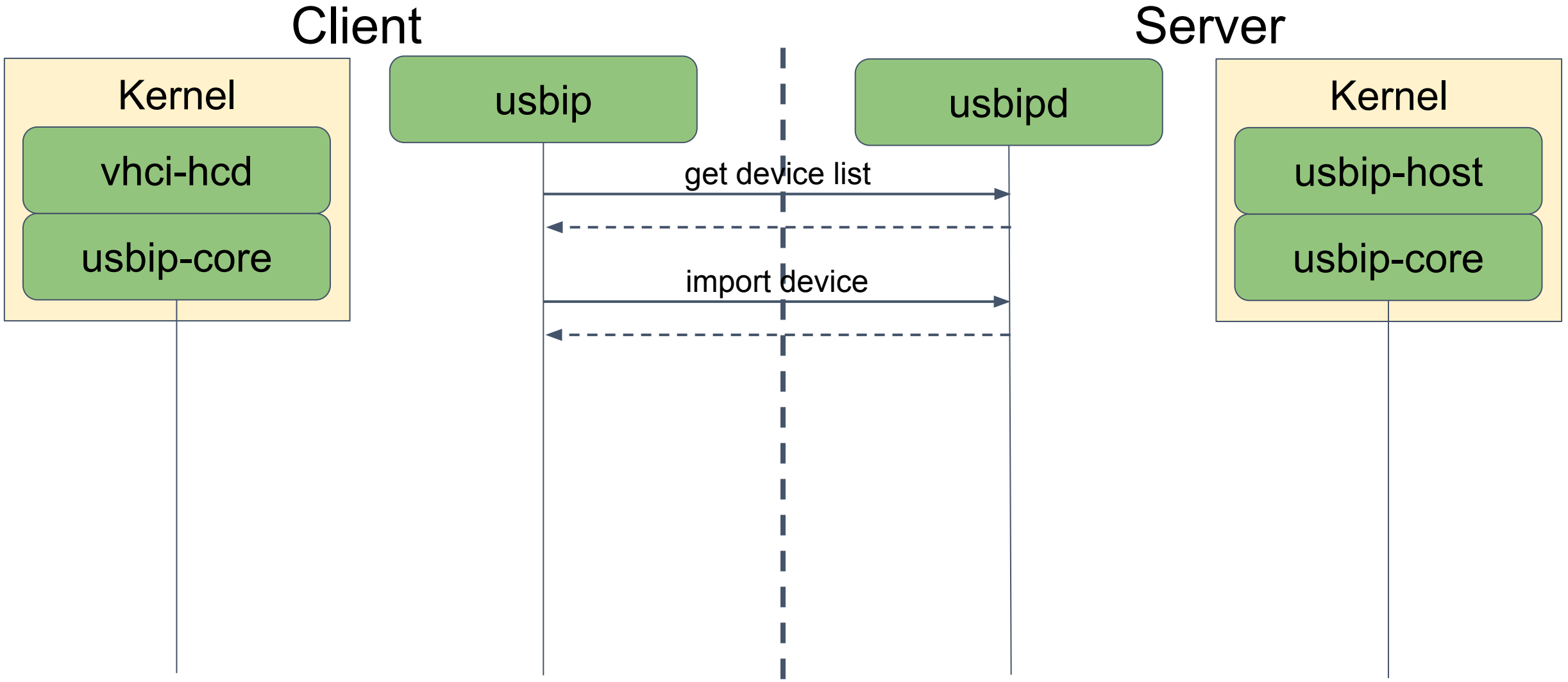

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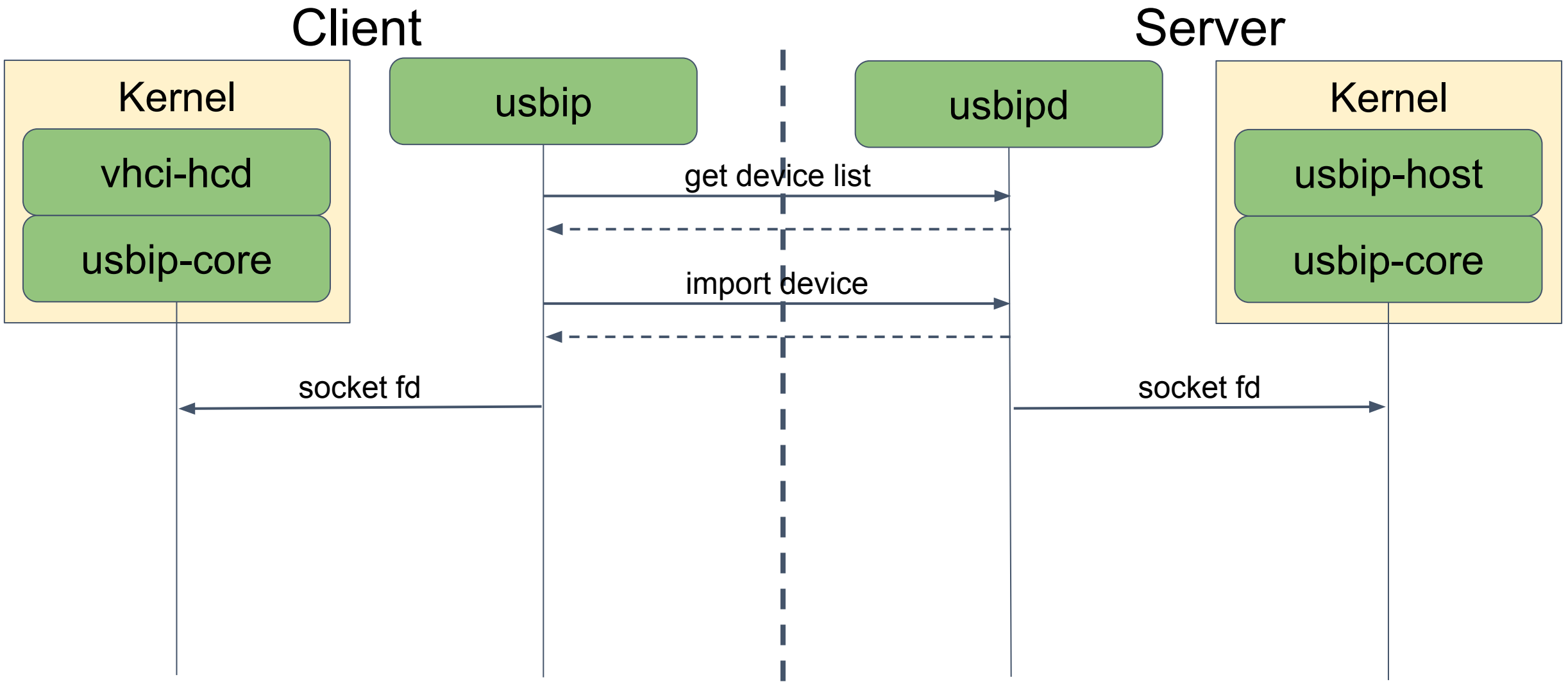

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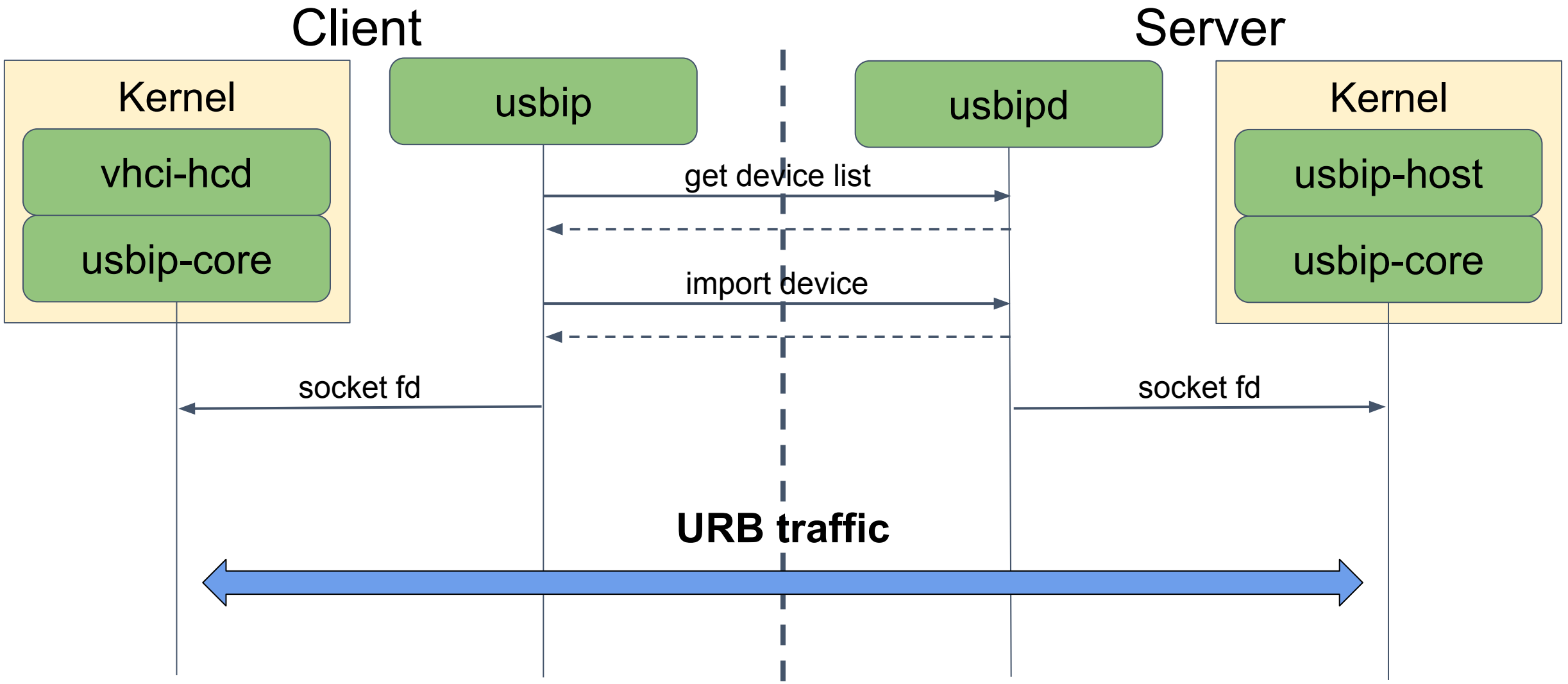

Vulnerable USB/IP code

USB/IP network protocol

https://www.kernel.org/doc/Documentation/usb/usbip_protocol.txt

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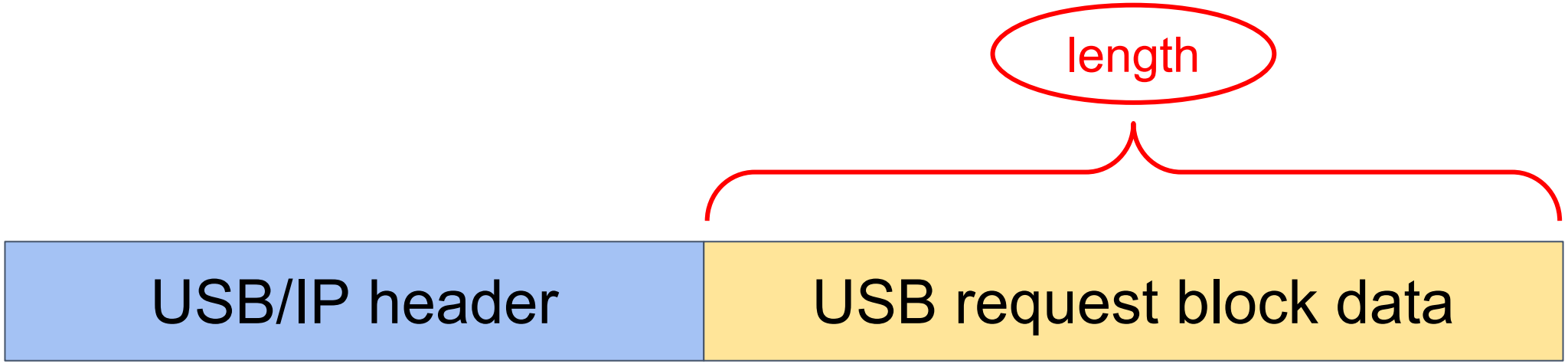

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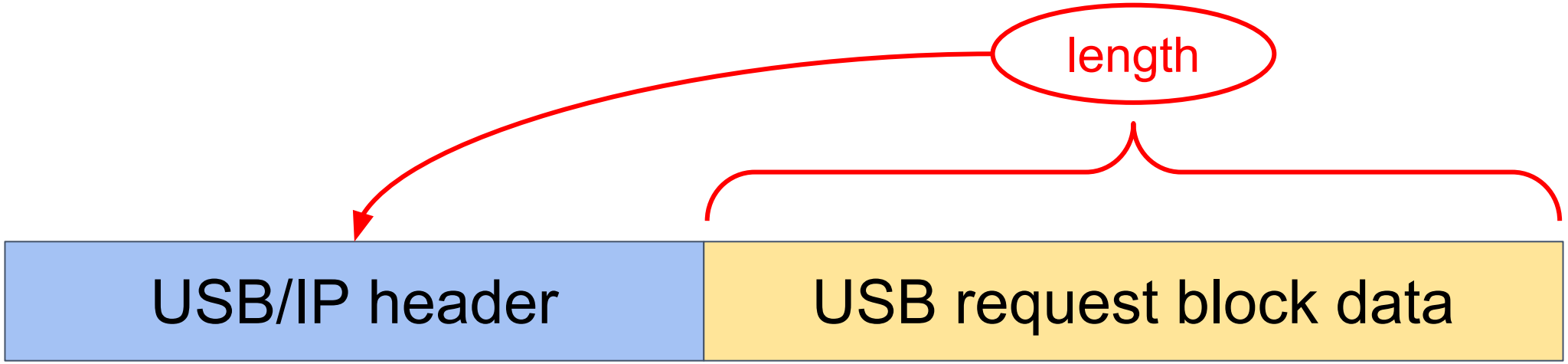

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USB/IP in Linux kernel

```
static void vhci_recv_ret_submit(struct vhci_device *vdev,
                                 struct usbip_header *pdu)
{
...
    /* unpack the pdu to a urb */
    usbip_pack_pdu(pdu, urb, USBIP_RET_SUBMIT, 0);

    /* recv transfer buffer */
    if (usbip_recv_xbuff(ud, urb) < 0)
        return;

...
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USB/IP in Linux kernel

```
static void usbip_pack_ret_submit(struct usbip_header *pdu, struct urb
*urb, int pack)
{
    struct usbip_header_ret_submit *rpdu = &pdu->u.ret_submit;

    if (pack) {
        ...
    } else {
        urb->status          = rpdu->status;
        urb->actual_length     = rpdu->actual_length;
        urb->start_frame     = rpdu->start_frame;
        urb->number_of_packets = rpdu->number_of_packets;
        urb->error_count     = rpdu->error_count;
    }
}
```

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    }
}
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USB/IP in Linux kernel

```
int usbip_recv_xbuff(struct usbip_device *ud, struct urb *urb)
{
    int ret;
    int size;

    if (ud->side == USBIP_STUB) {
        ...
    } else {
        ...
        size = urb->actual_length;
    }

    ...

    ret = usbip_recv(ud->tcp_socket, urb->transfer_buffer, size);
```

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- **`urb->transfer_buffer`** is usually allocated either by USB core code or USB device driver
- **`urb->transfer_buffer`** is allocated on request submit, so always assumes some maximum length
- According to USB/IP protocol the packet with “large” amount of data is valid

USB/IP in Linux kernel

It is possible to write arbitrary length data to `urb->transfer_buffer`

- Introducing **CVE-2016-3955**

USB/IP in Linux kernel

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- CVSS base score: 9.8 (*v. 3.0*) and 10 (*v. 2.0*)

USB/IP in Linux kernel

It is possible to write arbitrary length data to `urb->transfer_buffer`

- Introducing **CVE-2016-3955**
- CVSS base score: 9.8 (*v. 3.0*) and 10 (*v. 2.0*)
- **UBOAT** = [U]SB/IP [B]uffer [O]verflow [AT]tack

Requisites

- Victim has to actually use USB/IP

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- Victim has to actually use USB/IP
- Victim has to be a client in USB/IP terminology
- Victim has to “import” at least one USB device
- Attacker either has to control USB/IP server or do a MiTM on the network


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Demo

Potential exploit impact

Linux kernel heap exploit

- DoS: crash USB/IP client

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- Data injection

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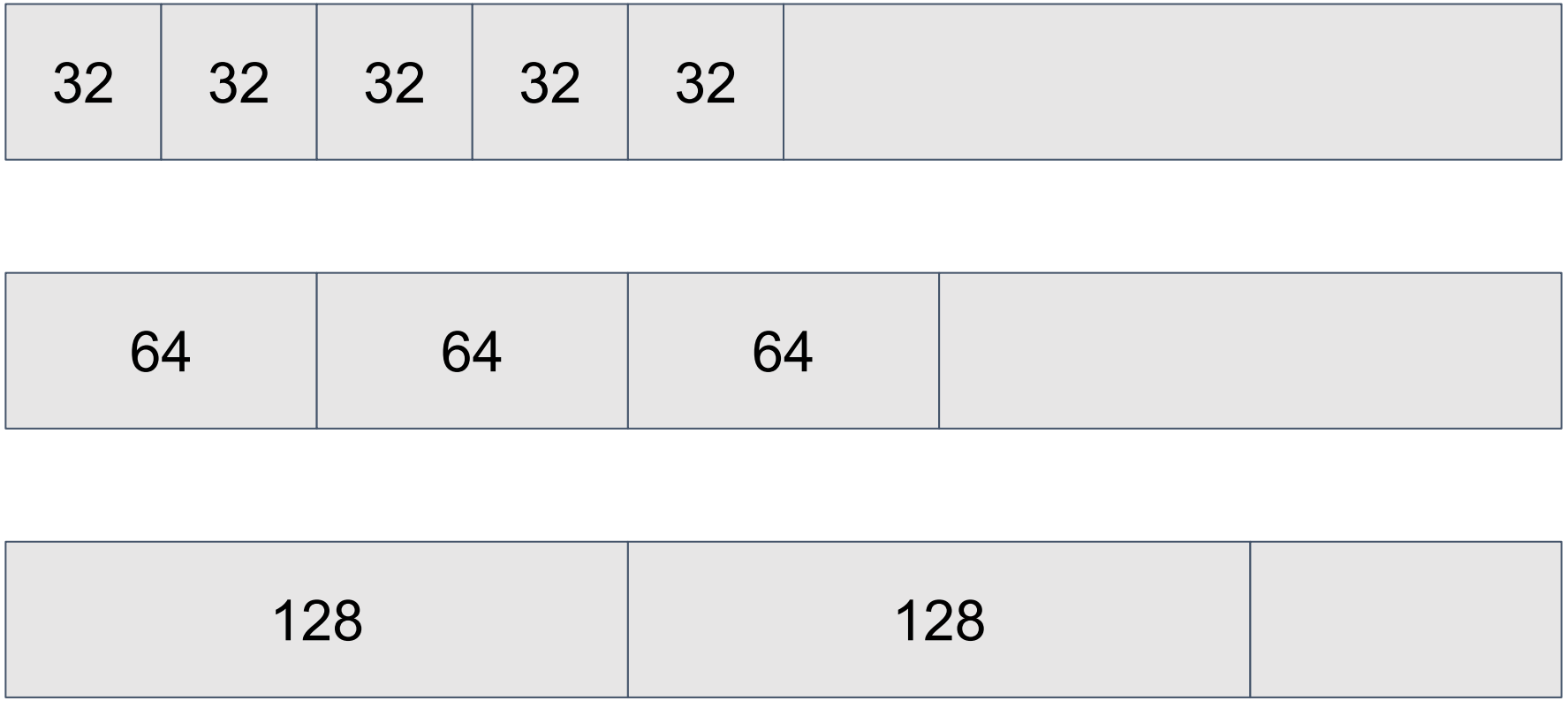
https://jon.oberheide.org/blog/2010/09/10/linux-kernel-can-slub-overflow/

Linux SLUB caches



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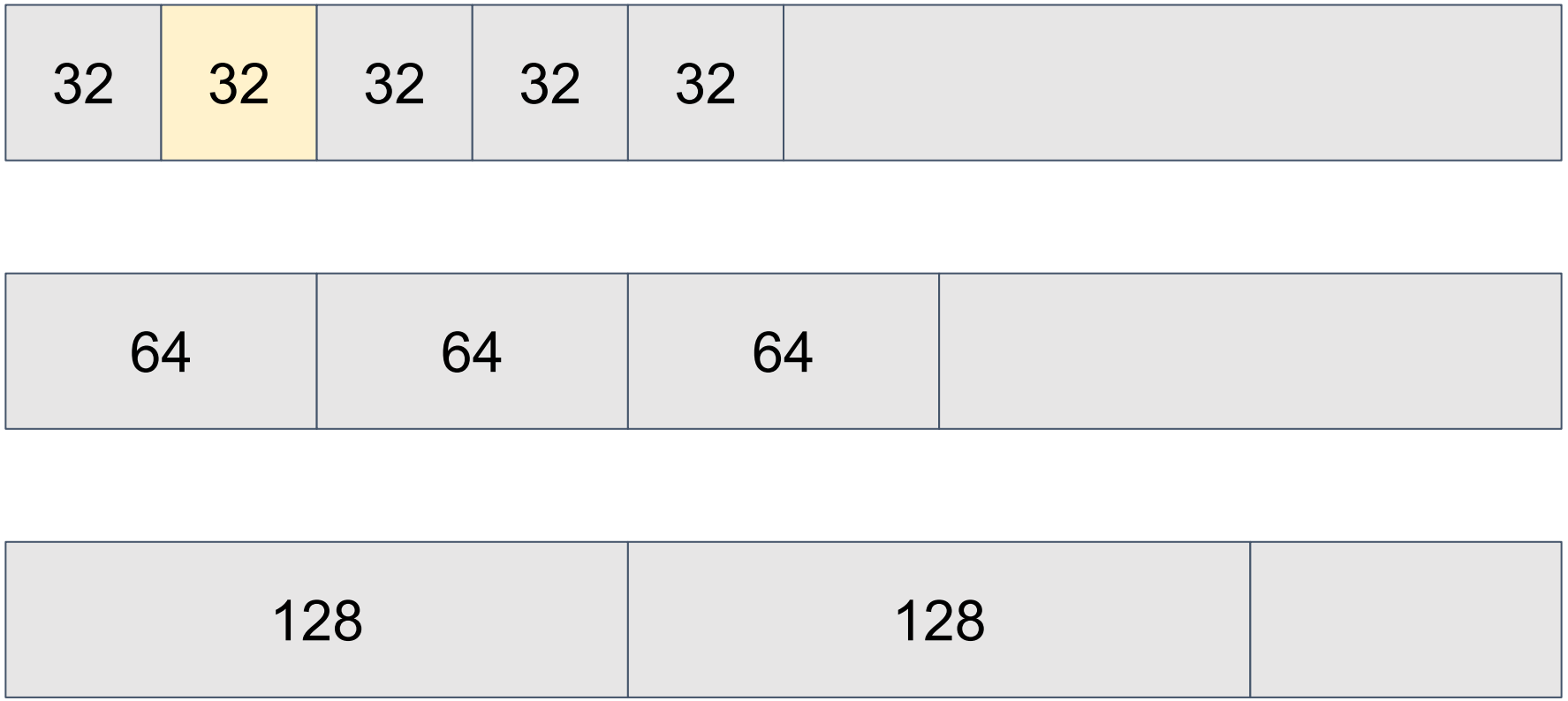

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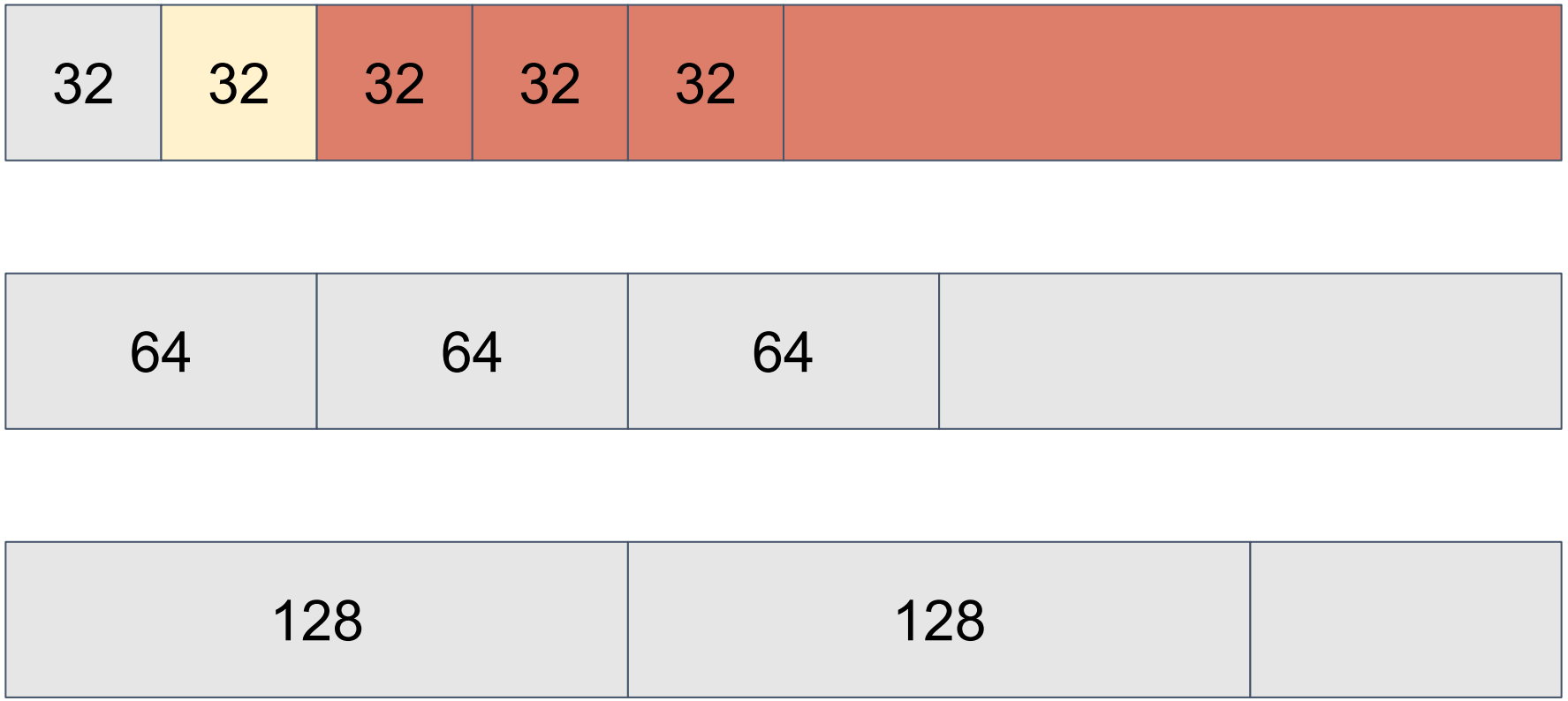

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- Find out which USB device drivers are using the same cache size as the desired object to be exploited

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- Emulate the device from the USB/IP server or by modifying USB/IP network traffic

Linux SLUB caches

- Find out which USB device drivers are using the same cache size as the desired object to be exploited
- Emulate the device from the USB/IP server or by modifying USB/IP network traffic
- Perform the buffer overflow

Hardening USB/IP setups

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- Reconsider

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- Patch your system

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- Protect your traffic (TLS, IPSec)
  - even in intranet
- Ensure your USB/IP server is trustworthy with proper ACLs

Resources

- https://pqsec.org/uboat-CVE-2016-3955/
- https://github.com/pqsec/uboatdemo
- https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2016-3955
- https://nvd.nist.gov/vuln/detail/CVE-2016-3955

Black Hat Sound Bytes

- Never sacrifice security for performance
  - extra buffer copy is not an excuse to move everything to kernel space
- Validate your input
- Consider least privilege principle
  - break code into modules
  - pay more attention to high-privileged code


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Thank you