

# What's the best practice for implementation of rumpclient?

Kazuya GODA  
<K-goda@iij.ad.jp>

# Agenda

- Introduce
- Preliminary knowledge
  - rumpkernel/client, OpenFlow and switch(4)/switch(8)
- Why I took rump kernel to develop switch(4)
- How to implement rump kernel client
- Let's practice
- Conclusions

# Who am I?

- Kazuya GODA
- Work at IJ as software engineer
  - I've worked on SEIL team , using NetBSD, and Tornado team, using OpenBSD
- OpenBSD developer <goda@openbsd.org>
  - But I'll only talk about NetBSD today

# Introduction

- I'm porting switch(4)/switch(8) from OpenBSD
  - switch(4) is an implementation of OpenFlow switch
- I've used rumpkernel to develop it
  - I have to work not only switch(4) but also switch(8) in rump
    - In other word, I have to implement switch(8) as rumpclient
- I've gotten some knowledges from this work
  - I'll share it with you

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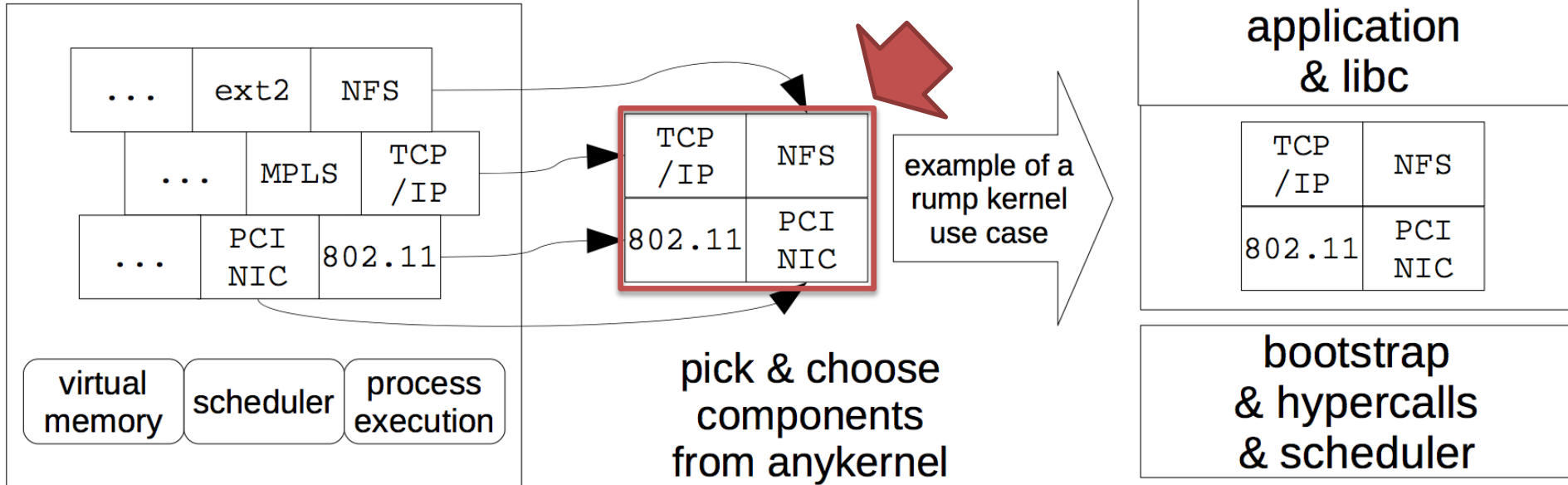
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# Rump kernel

*anykernel*

*rump kernel*

*Rumprun unikernel*



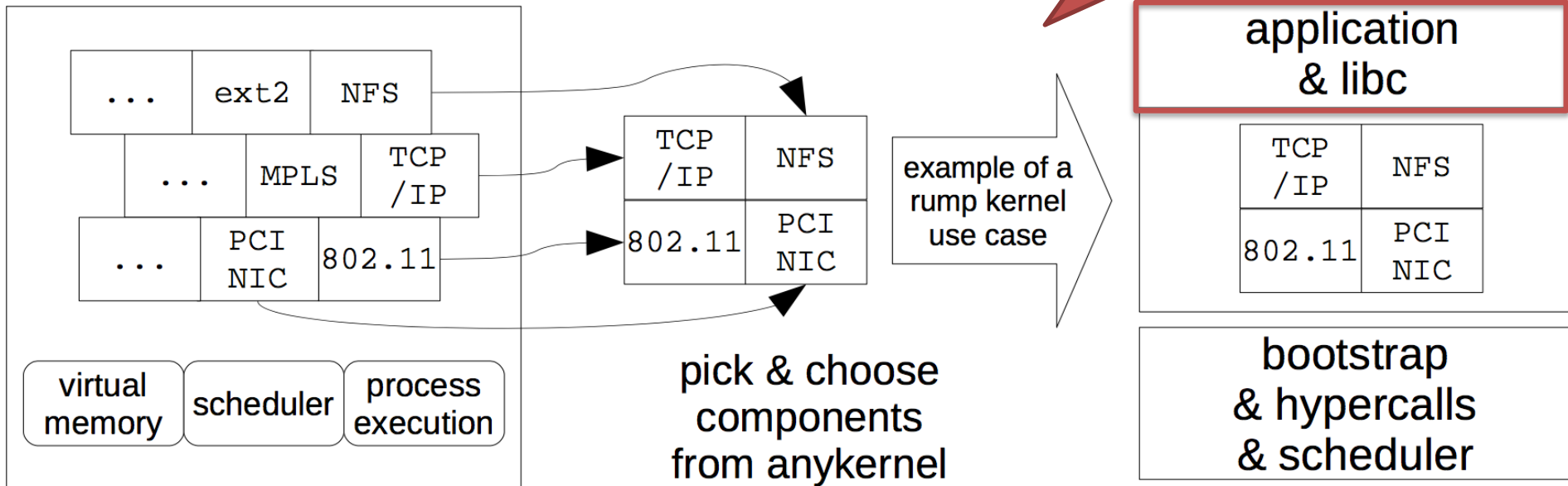
\* Figure 2.4: Client types illustrated , THE DESIGN AND IMPLEMENTATION OF THE ANYKERNEL AND RUMP KERNELS

# Rump kernel client

*anykernel*

*rump kernel*

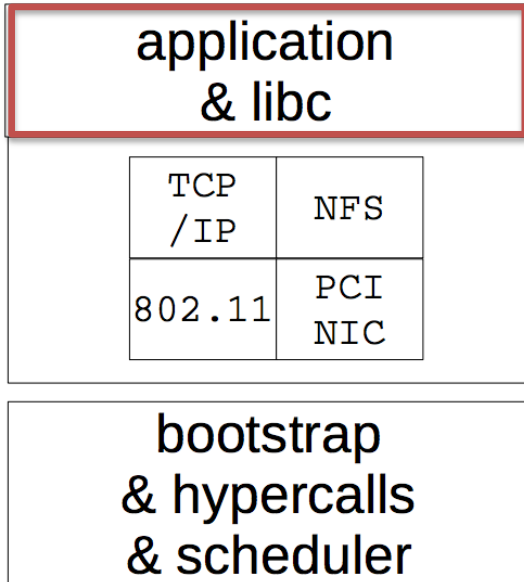
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# Rump Kernel Client

*Rumprun unikernel*

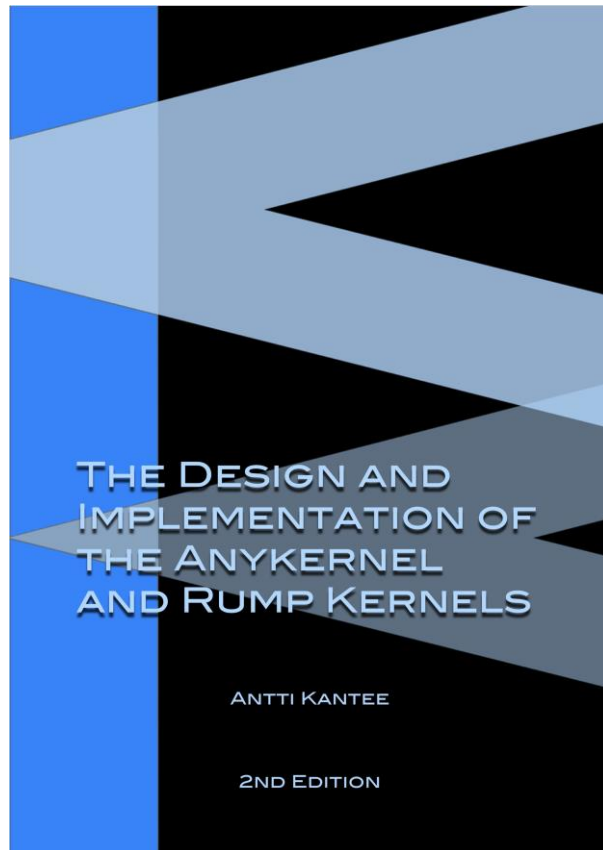


- Request something from a rump kernel
  - It's an example application that be using TCP/IP stack and NFS etc...
- 3 types of rump kernel client
  - local, remote, microkernel



# You Want to get more detail

- You must read the book
  - There're over 200 pages in the book
- THE DESIGN AND IMPLEMENTATION OF THE ANYKERNEL AND RUMP KERNELS
  - <http://www.fixup.fi/misc/rumpkernel-book/>



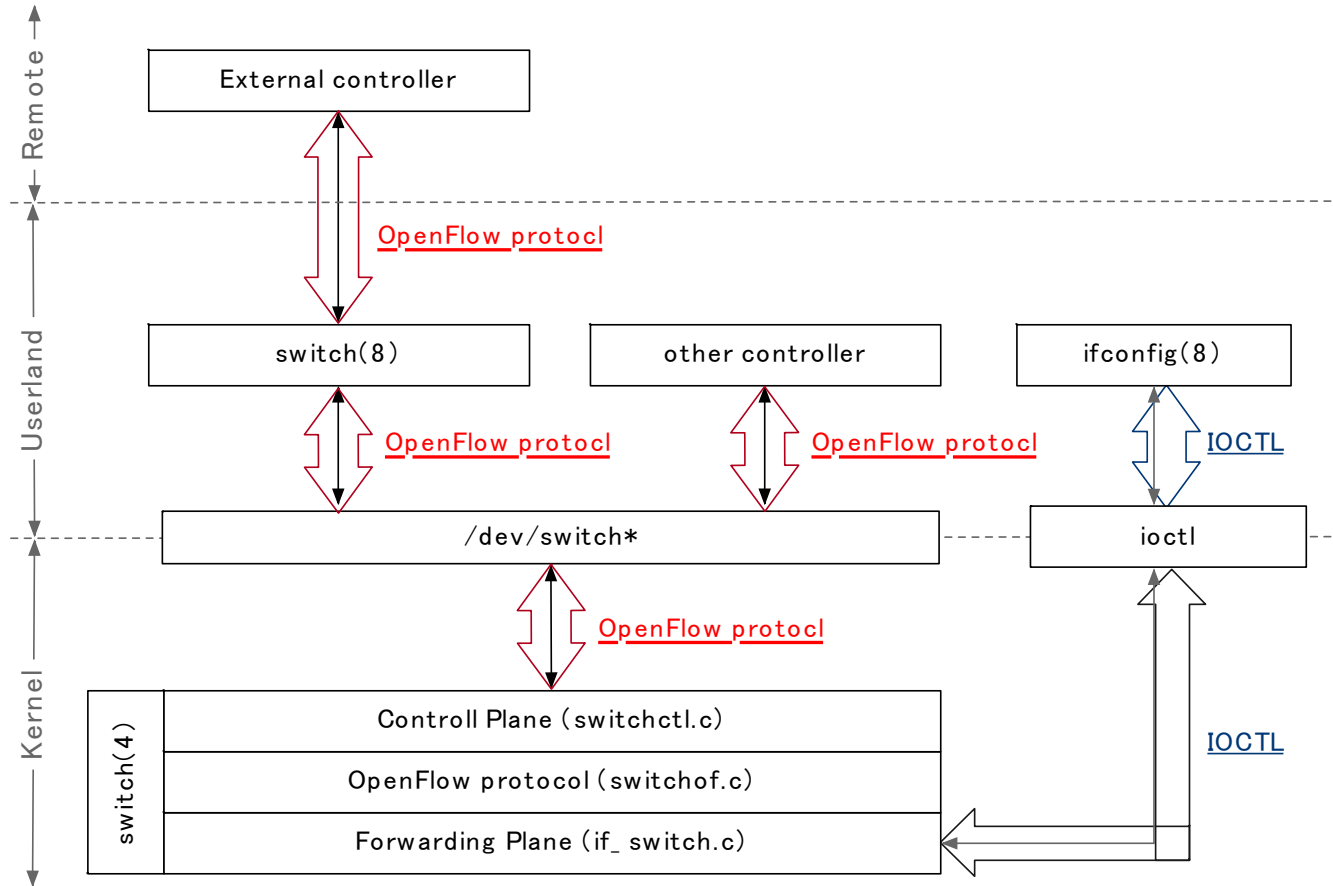
# OpenFlow protocol

- OpenFlow is considered one of the first SDN standards
- Communication protocol that enable the SDN controller to directly interact with the forwarding plane

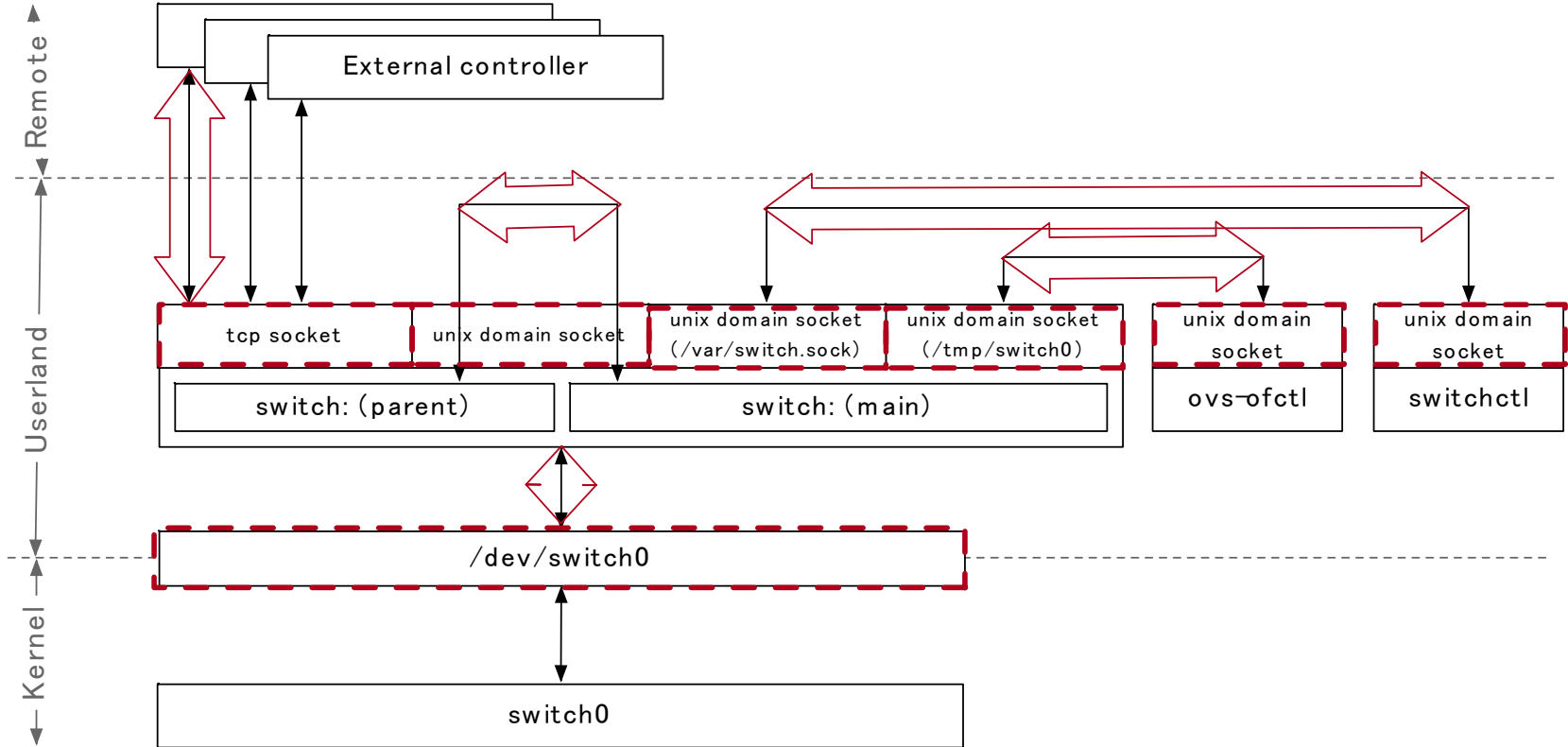
## switch(4)/switch(8)

- switch(4) is much the same as bridge(4) except that has capability of OpenFlow switch
  - switch(4) can work OpenFlow switch itself
- switch(8) proxy OpenFlow channel between OpenFlow controller and switch(4)

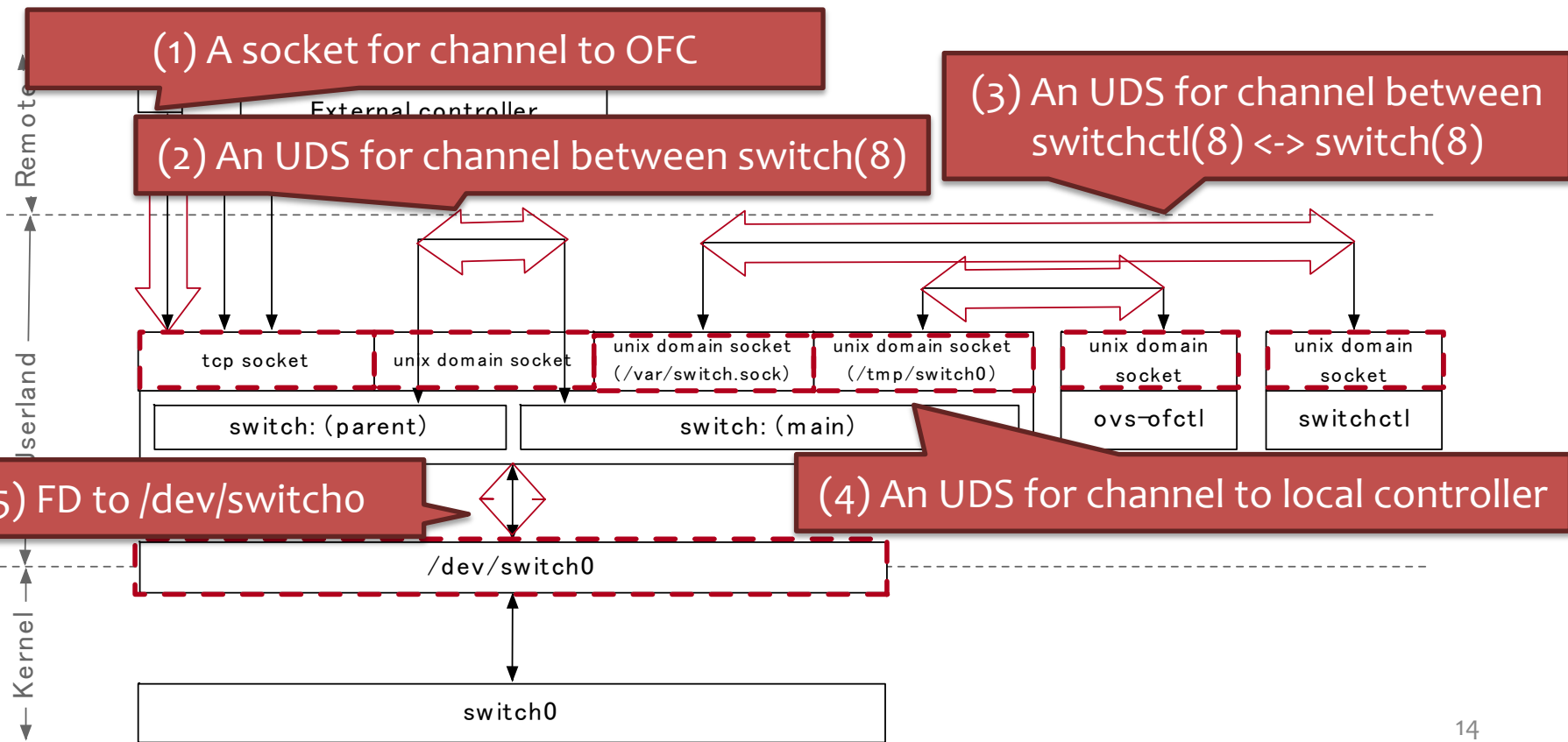
# Architecture of switch(4)/switch(8)



# I/O resources of switch(8)



# I/O resources of switch(8)



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- **Why I took rump kernel to develop switch(4)**
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# Why I took rump kernel to develop switch(4)

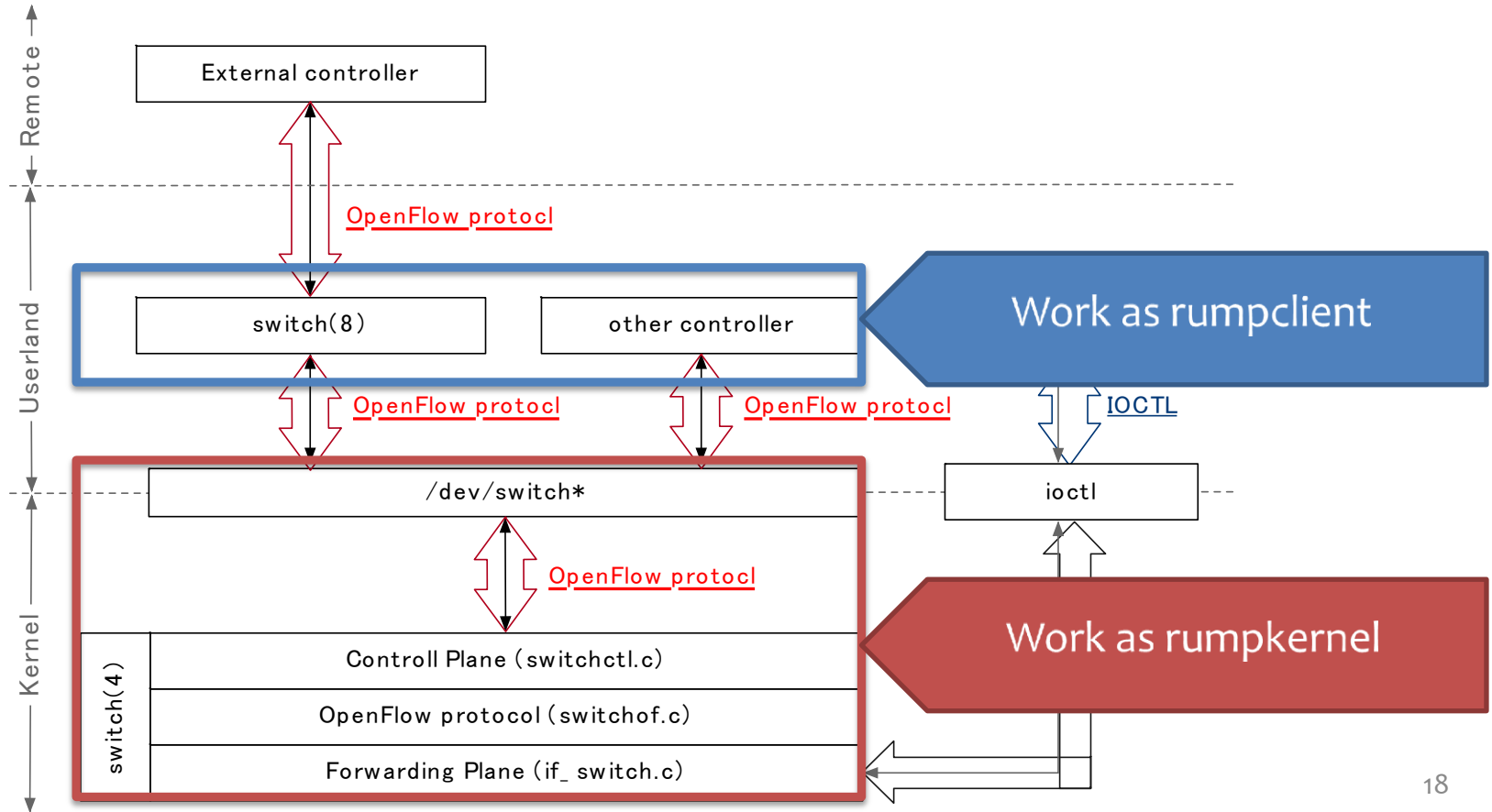
- If switch(4) runs on rump kernel
  1. It can be easy to develop / debug to switch(4)
  2. It can use some debug / profile tools such as Valgrind
  3. It can be useful for development of switch(8)



# Goal

1. `switch(4)` can work on rump kernel
2. `switch(8)` can communicate `switch(4)` in rump kernel
  - Any OFCs can communicate `switch(4)` in rump kernel via `switch(8)`
3. Avoid modifying `switch(8)` as much as possible
  - It's decided by my own mind that how much it can modify

# Architecture of switch(4)/switch(8)

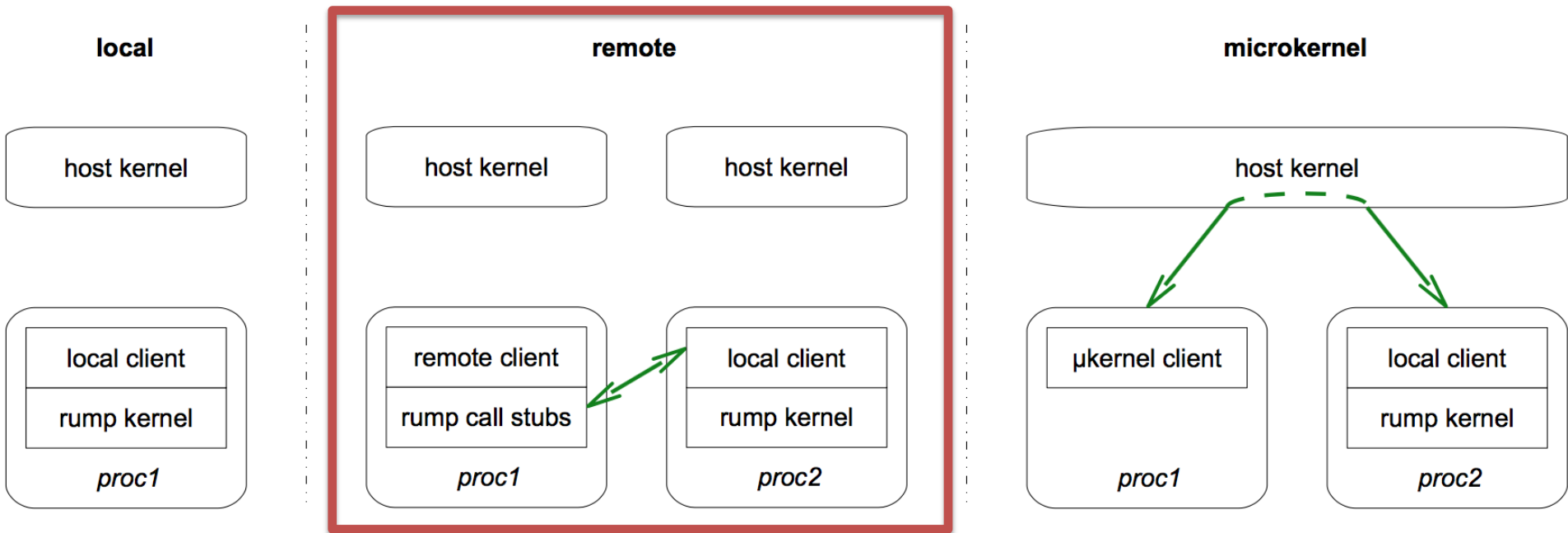


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# 3 Types of Rump Kernel Client

- I've selected remote

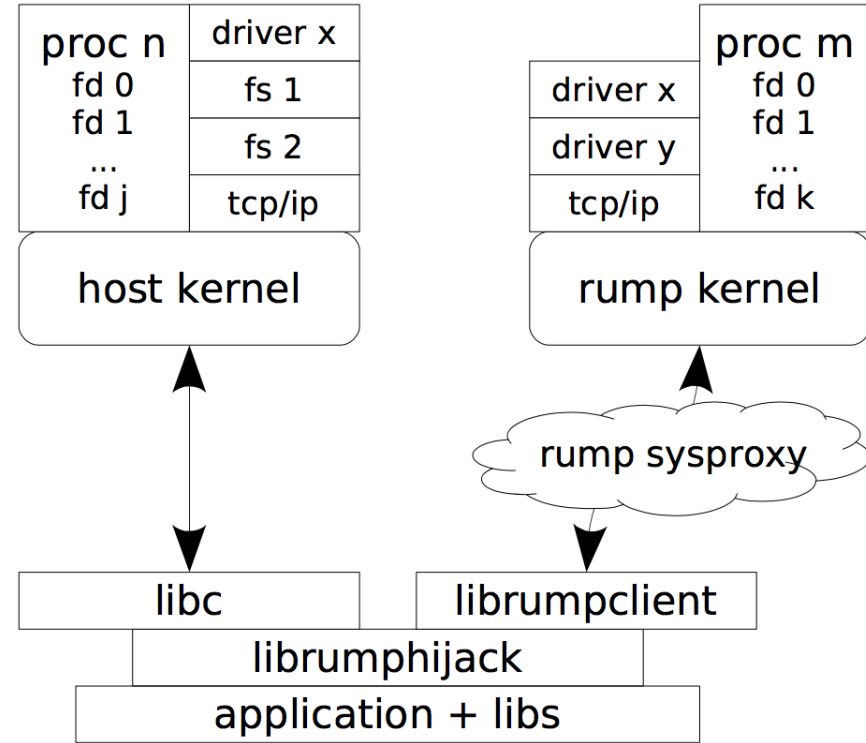


## 2 way implementation of remote client

- Use librumphijack
  - Hijacks host system call by LD\_PRELOAD
  - Not need any modify for rump kernel client
- Modify application to work as rump kernel client

# librump hijack

- librump hijack hijacks system call and proxy it to rump kernel

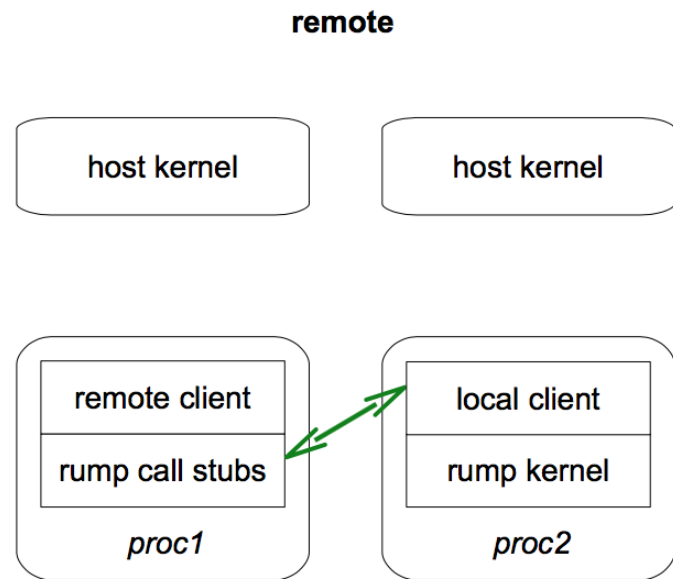


# Modify application to work as rump kernel client

```
int
main(int argc, char *argv[])
{
    [...]
    /* bootstrap rump kernel */
    rump_init();

    /* open bpf device, fd is in implicit process */
    if ((fd = rump_sys_open(_PATH_BPF, O_RDWR, 0)) == -1)
        err(1, "bpf open");

    /* set bpf to use it */
    strncpy(ifr.ifr_name, "virt0", sizeof(ifr.ifr_name));
    if (rump_sys_ioctl(fd, BIOCSETIF, &ifr) == -1)
        err(1, "set if");
    [...]
}
```

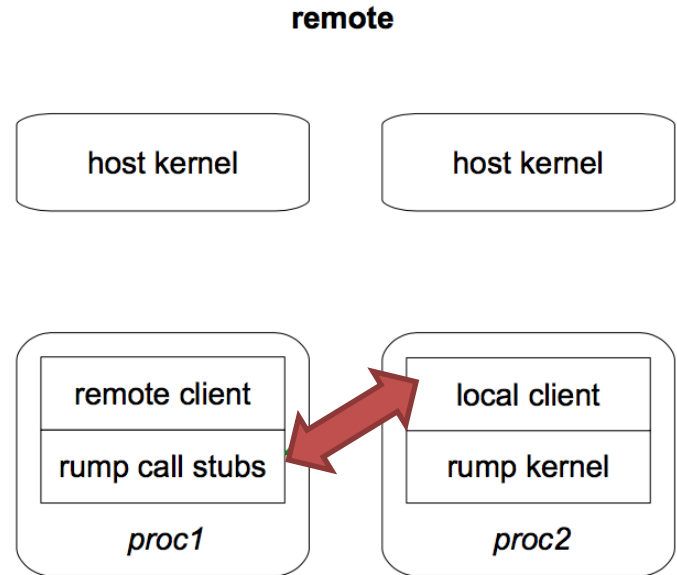


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    [...]
}
```



Rump call stubs (librumpclient) proxys system call



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# Attempt 3 ways to work switch(8) as rump client

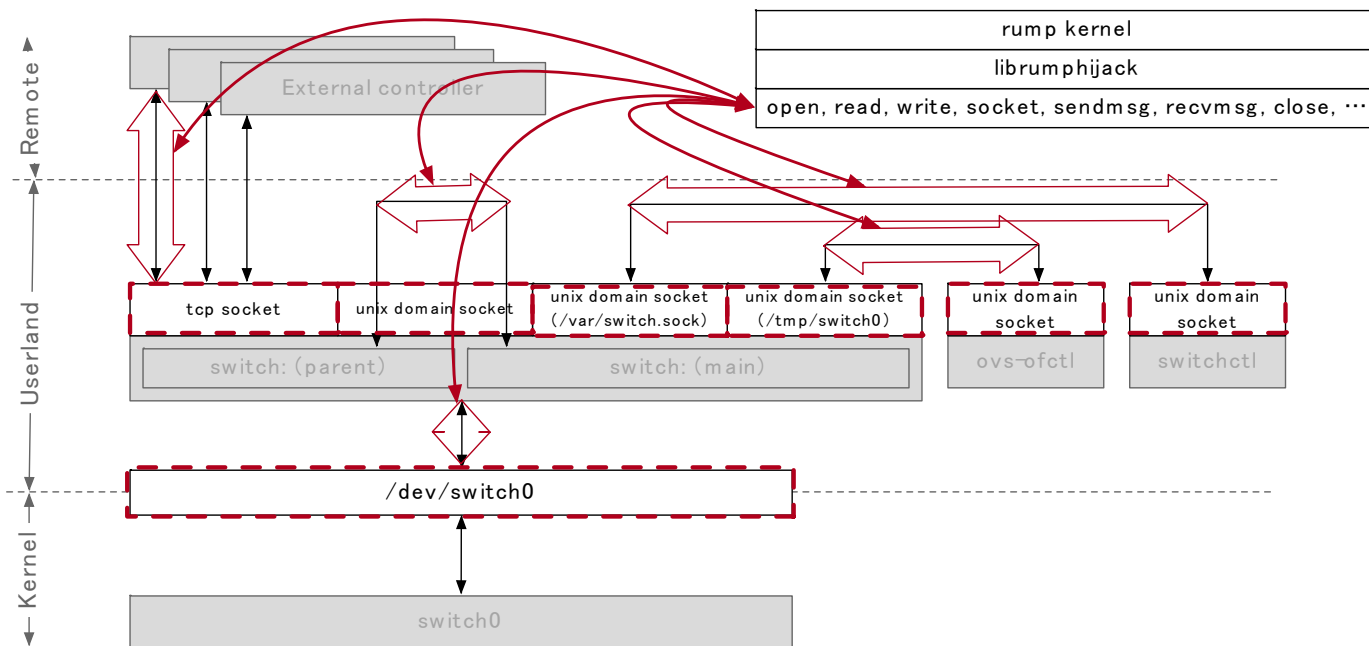
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2. Modify switch(8) for rump kernel client
3. Put I/O Proxy daemon between switch(4) and switch(8)

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1. Apply librumphijack
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# Apply librumphijack

- Fortunately, switch(8) only calls rumpkernel-supporting system calls



# Couldn't get good result...

- rumphijack doesn't support kqueue/kevent
  - \*) rump kernel supports kevent/kqueue
- A Comment at kevent() in librumhijack

```
/*  
 * Check that we don't attempt to kevent rump kernel fd's.  
 * That needs similar treatment to select/poll, but is slightly  
 * trickier since we need to manage to different kq descriptors.  
 * (TODO, in case you're wondering).  
 */
```

# Review

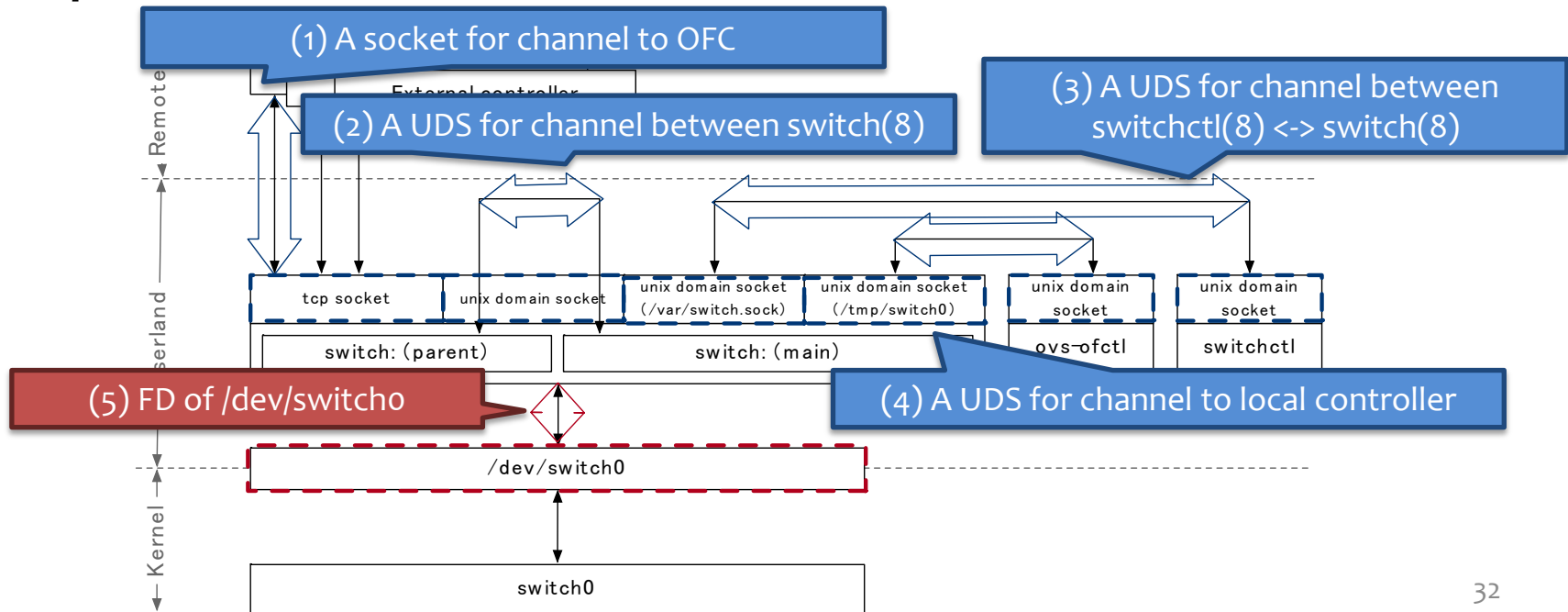
- That's how it goes
- The comment offers me to implement kqueue/kevent to rumpjack
  - But I guess it's a lot difficult so I didn't it at that moment
- I considered the other way

# Attempt 3 ways to work switch(8) as rump client

1. Apply librumphijack
  - Failed because it doesn't support kqueue/kevent
2. Modify switch(8) for rump kernel client
3. Put I/O Proxy daemon between switch(4) and switch(8)

Only calls rump kernel's system calls when I/O resources are rump kernel's

- Fortunately, only `/dev/switch0` communicates with rump kernel



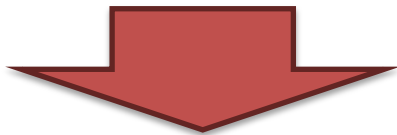


# Couldn't get any good results

- Not enough to consider using difference kernels
- It's difficult to achieve I/O multiplexer for difference kernels because it's necessary to work tricky

# What's difficult to handle I/O multiplexer?

- switch(8) has multiple I/O such as for /dev/switcho, OpenFlow Controller(OFC), etc...
  - switch(8) uses kqueue/kevent to I/O multiplexer
- The FD of channel between OFC is held by host kernel
- The FD of channel between switch(4) held by rump kernel



- It's impossible to handle I/O resources in difference kernels by the one kernel

# Review

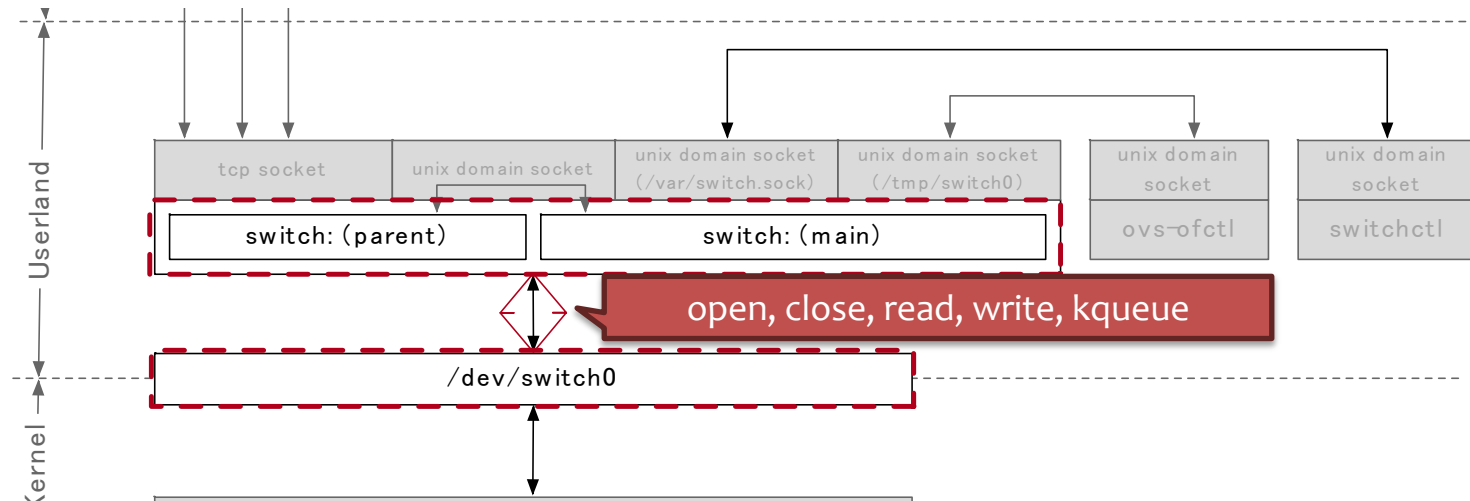
- An approach that handles different kernel's I/O seems not so good, especially I/O multiplexing
- switch(8) should only handle either I/O resources of rump's or host's
  - switch(8) linked a few external libraries such as libevent, so it have to replace every system call within external libraries
  - I never want to do it!!

# Attempt 3 ways to work switch(8) as rump client

1. Apply librumphijack
  - Failed because it doesn't support kqueue/kevent
2. Modify switch(8) for rump kernel client
  - Failed because it's too difficult to work I/O multiplexing
3. Put an I/O proxy daemon between switch(4) and switch(8)

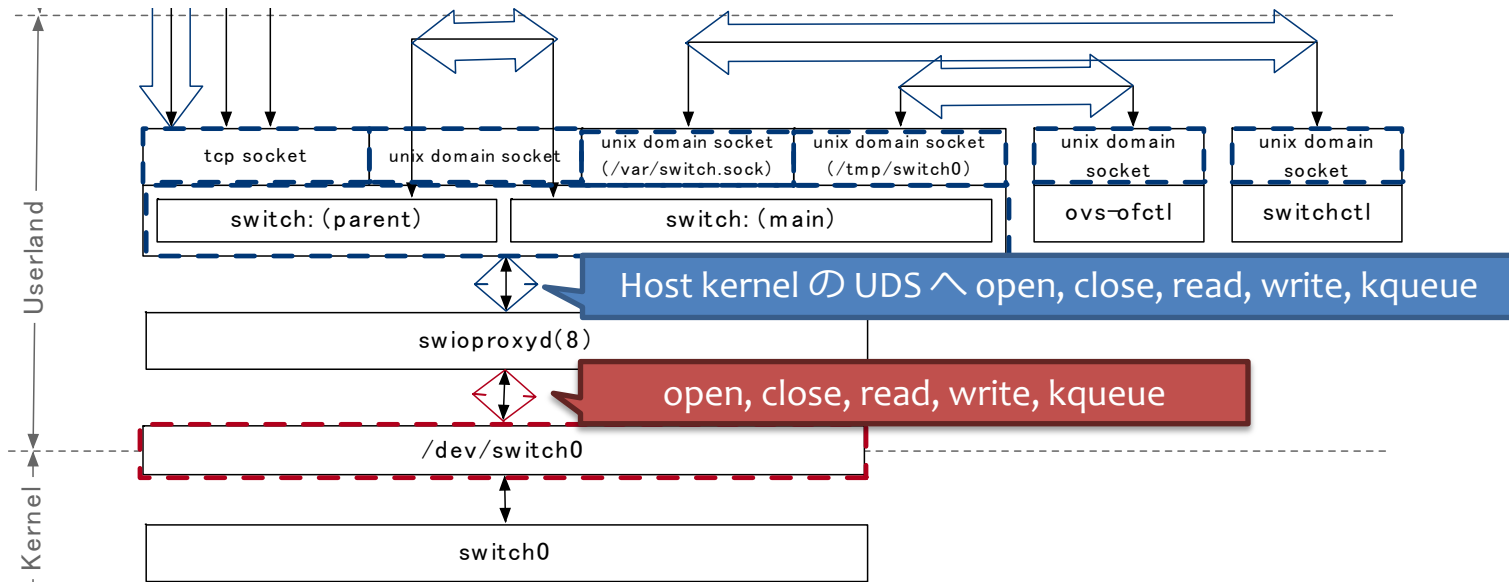
# An I/O Proxy Daemon between switch(4) and switch(8)

- Fortunately, called system calls for `/dev/switch0` are open, close, read, write, kqueue and kevent
- It can replace easily to Unix Domain Socket



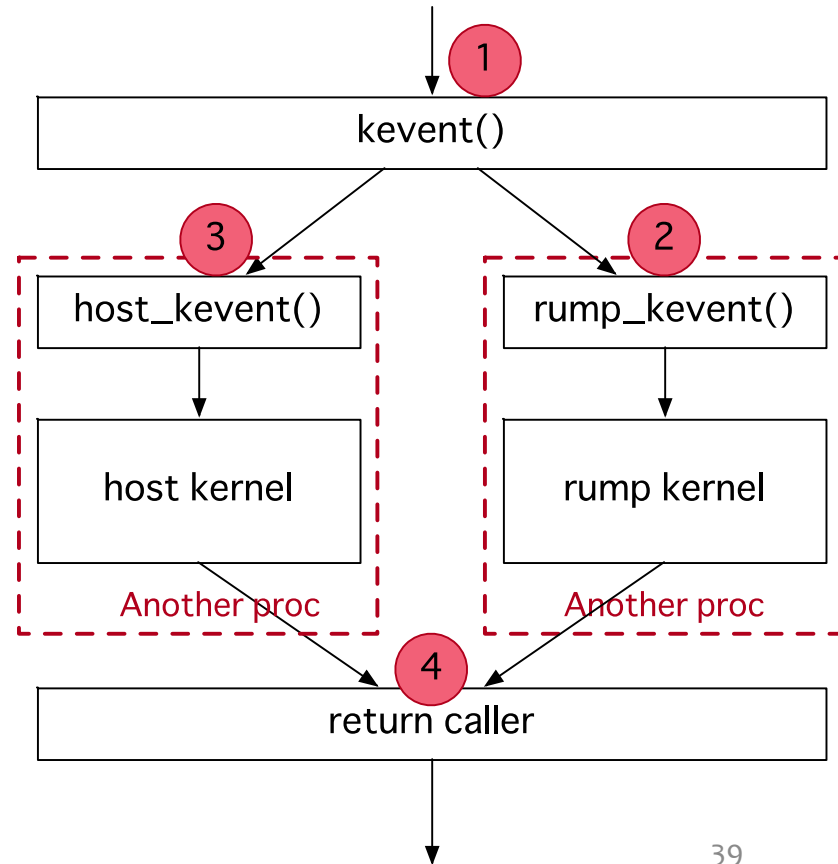
# swioproxyd(8)

- Communicate between switch(8) and swioproxyd(8) via Unix Domain Socket
- swioproxyd(8) proxys between switch(8) and rumpkernel



# swioproxyd(8)

1. Distinguish between rump's FDs and host's FDs
2. Produces a new thread and calls rump\_kevent()
3. Produces a new thread and calls host's kevent()
4. Wait for ready any FDs



# Review

- ✓ `switch(4)` can work on rump kernel
- ✓ `switch(8)` can communicate `switch(4)` in rump kernel
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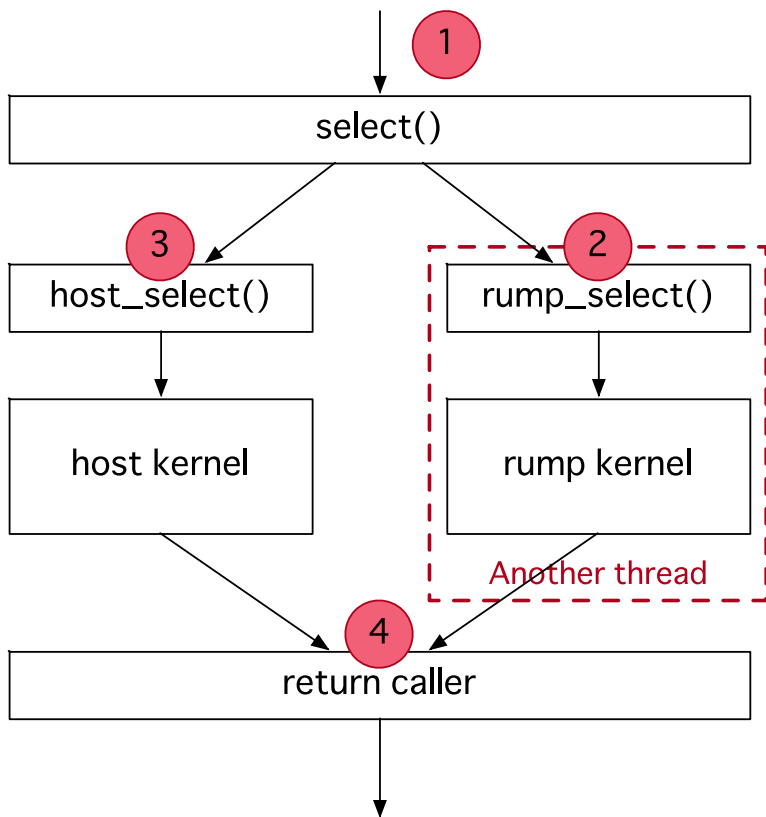


# Conclusion

- At any time, using rumphijack is 1st choice
  - But it doesn't work at a few cases such as switch(8)
- It doesn't produce good result to handle both rump and kernel I/O resource in the one program
- It's effective for linked some external libraries program to put on proxy

# appendix

# How to work select/poll in librumphijack



1. Distinguish between rump's FDs and host's FDs by checking `FD_SET`
2. Produces a new thread and calls `rump_select()`
3. Calls `select()` on Host kernel too
4. Wait for ready any FDs