Developing a Multiserver Operating System

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UINX.CZ

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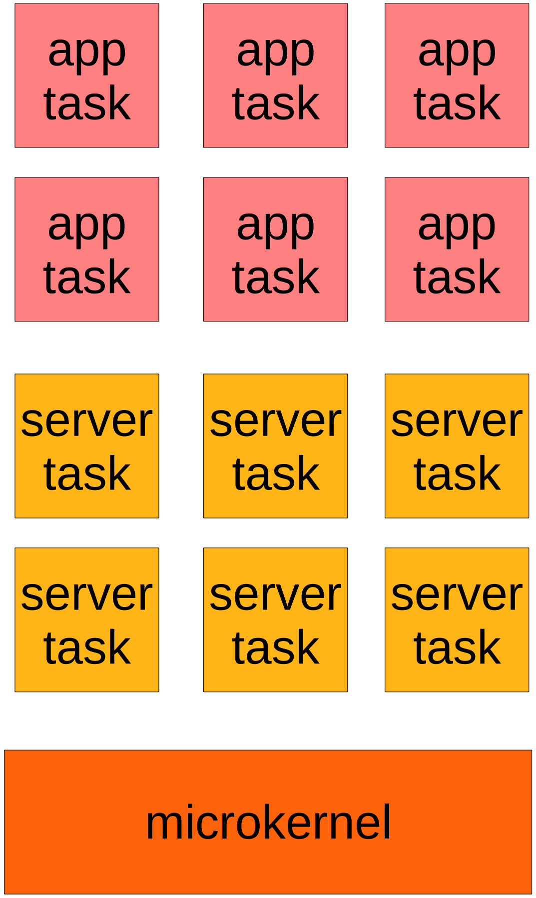

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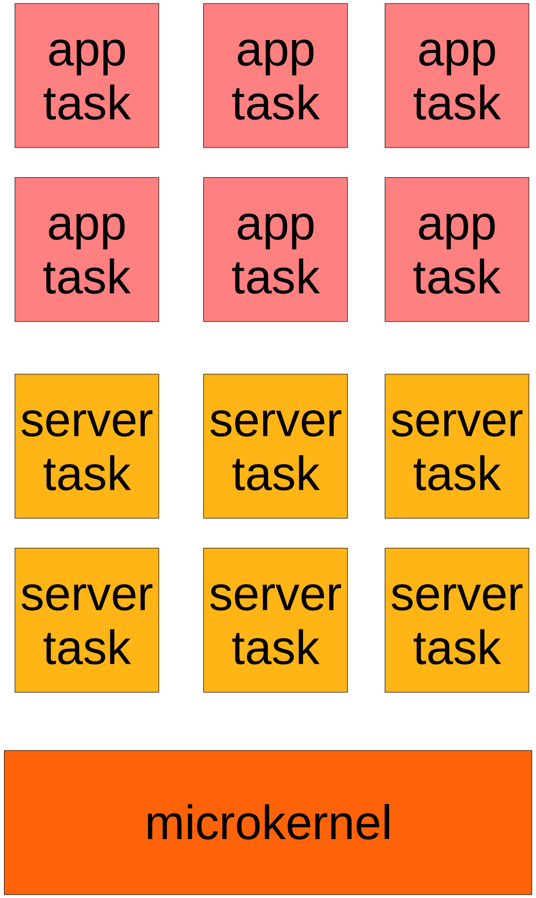

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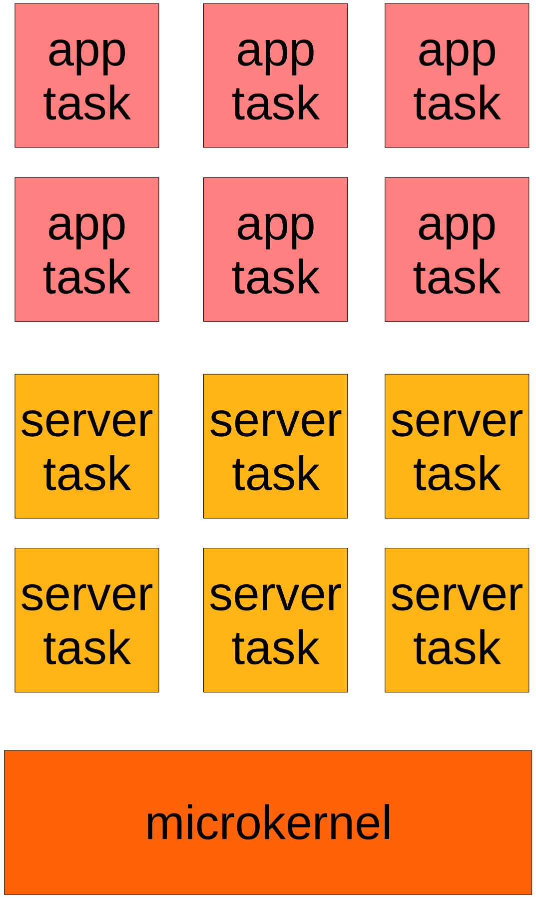

OS Classification by Architecture

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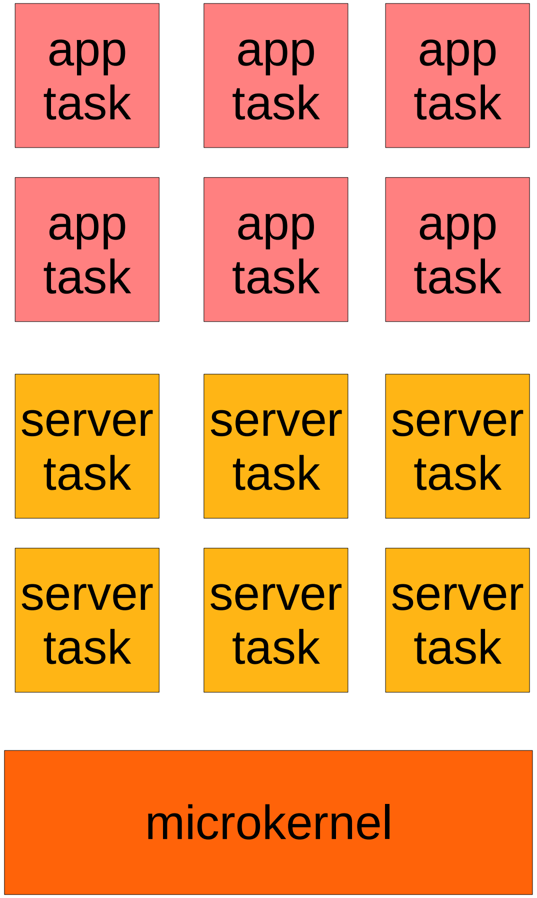

multiserver-
microkernel

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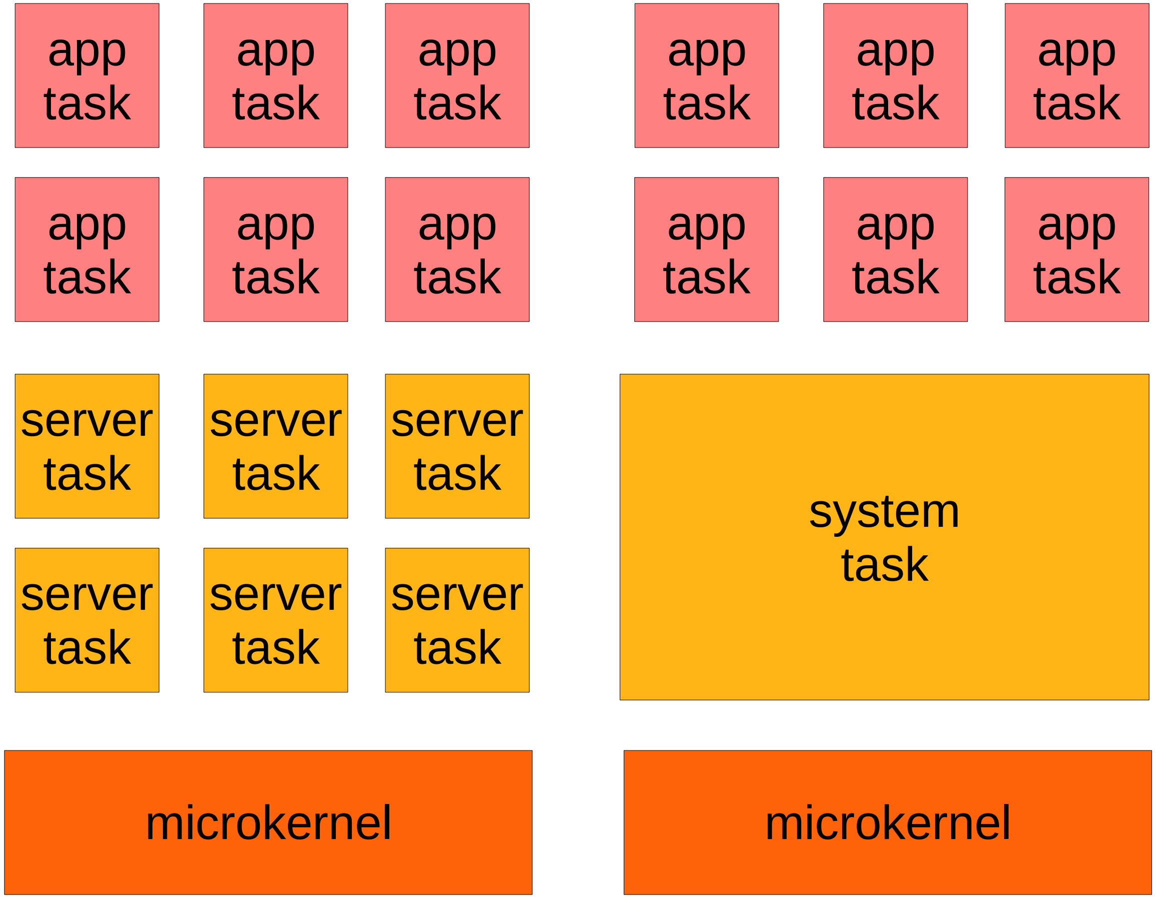

multiserver-microkernel

microkernel with single system task

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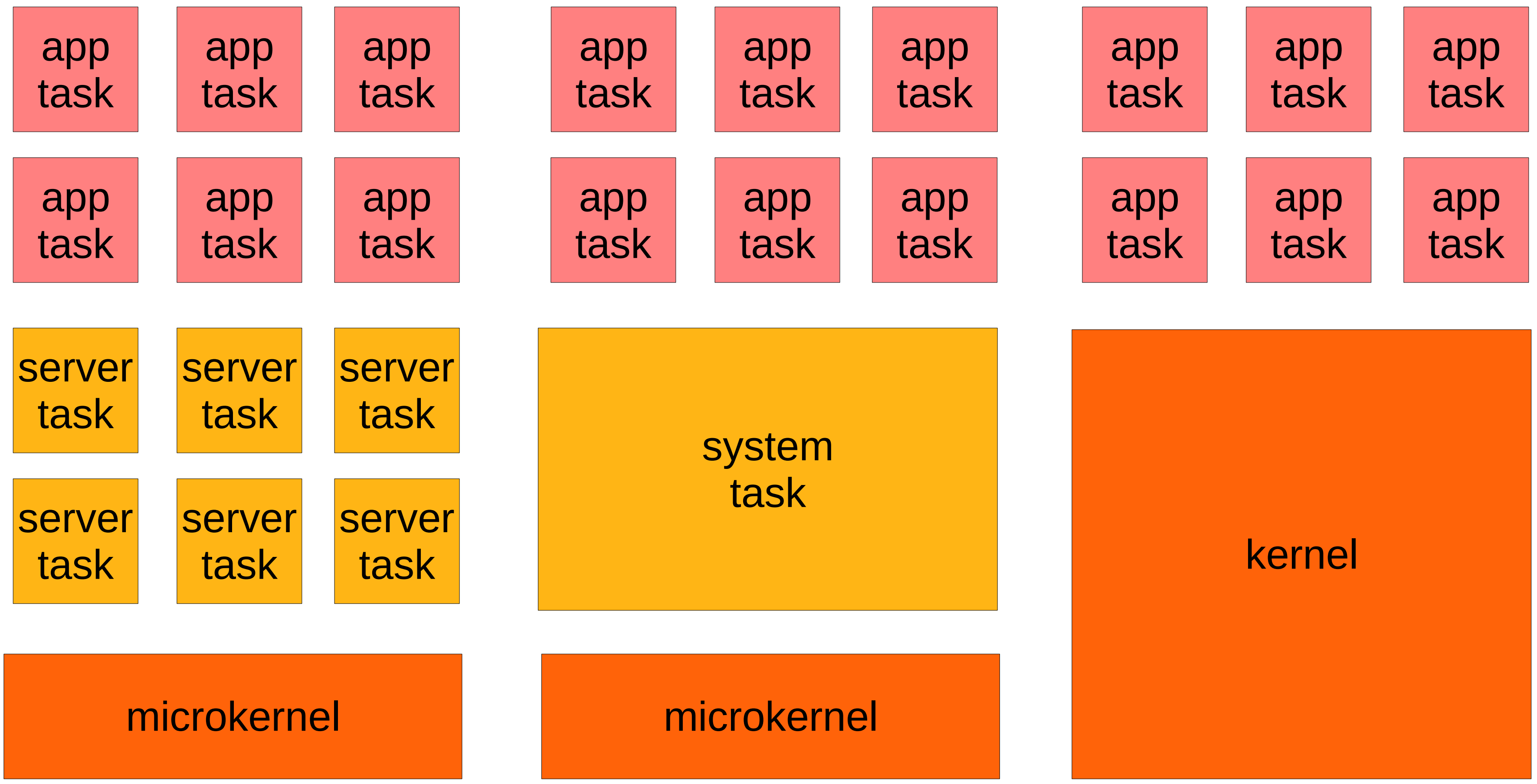

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microkernel with single system task

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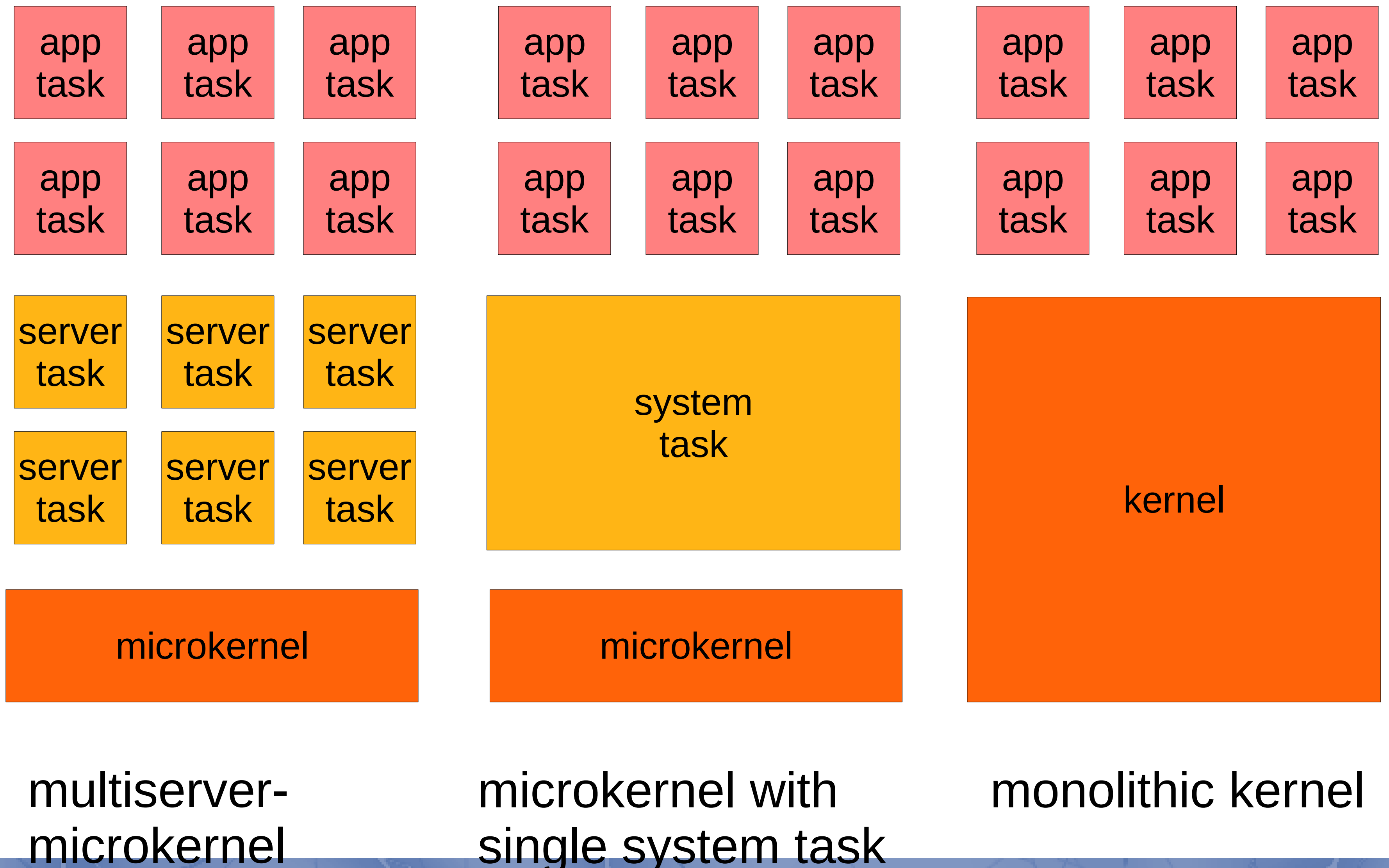

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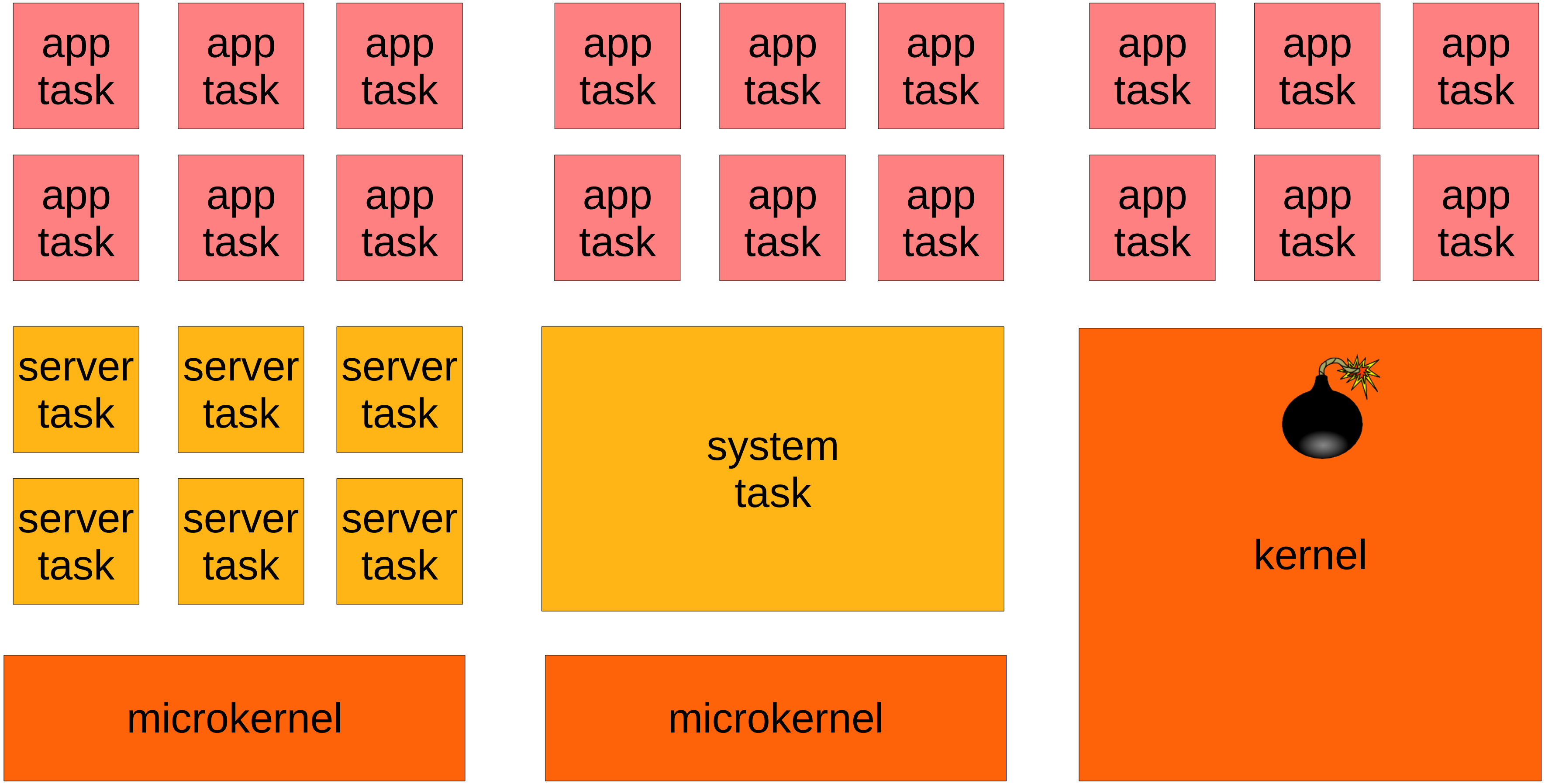

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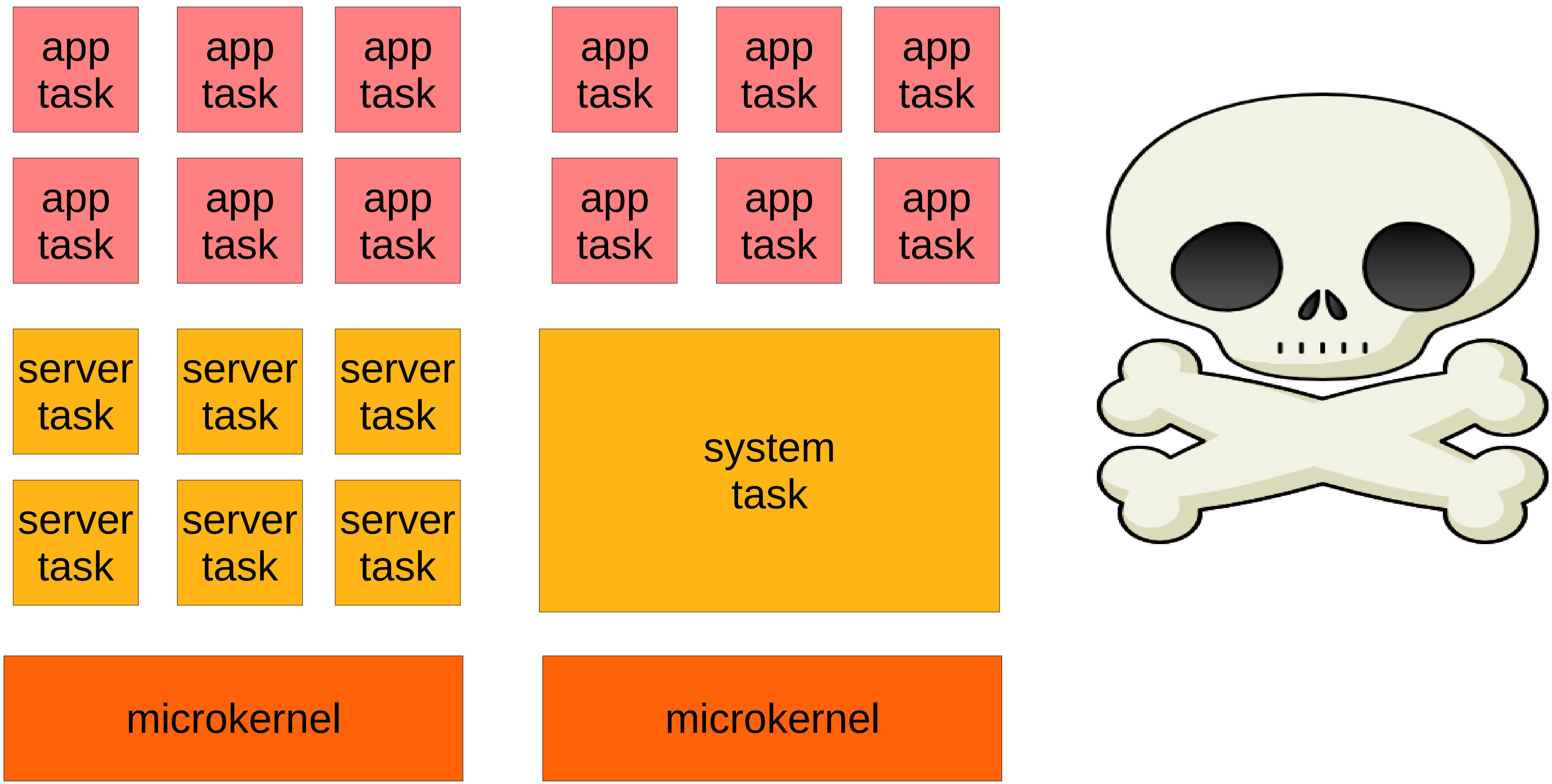

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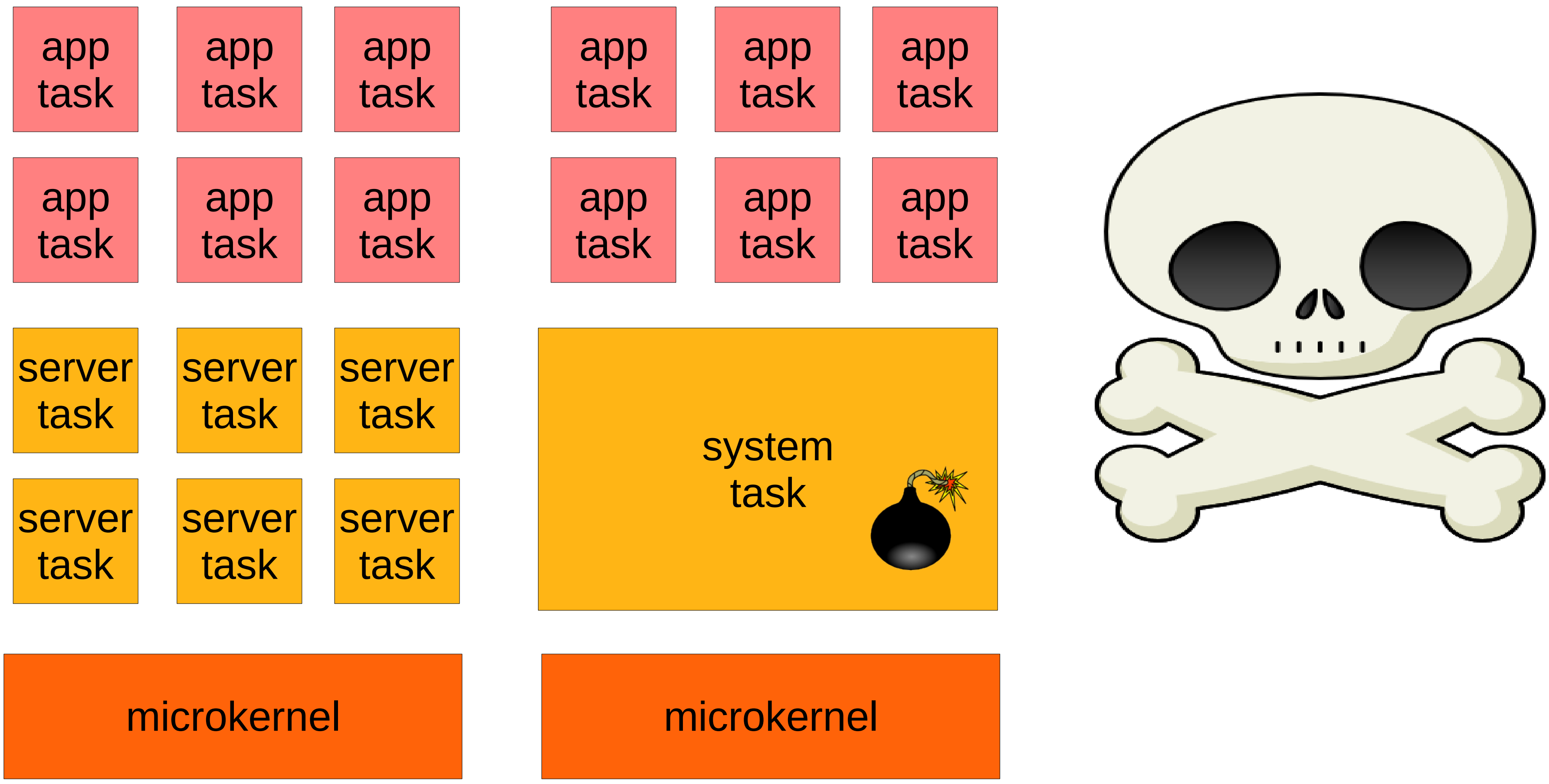

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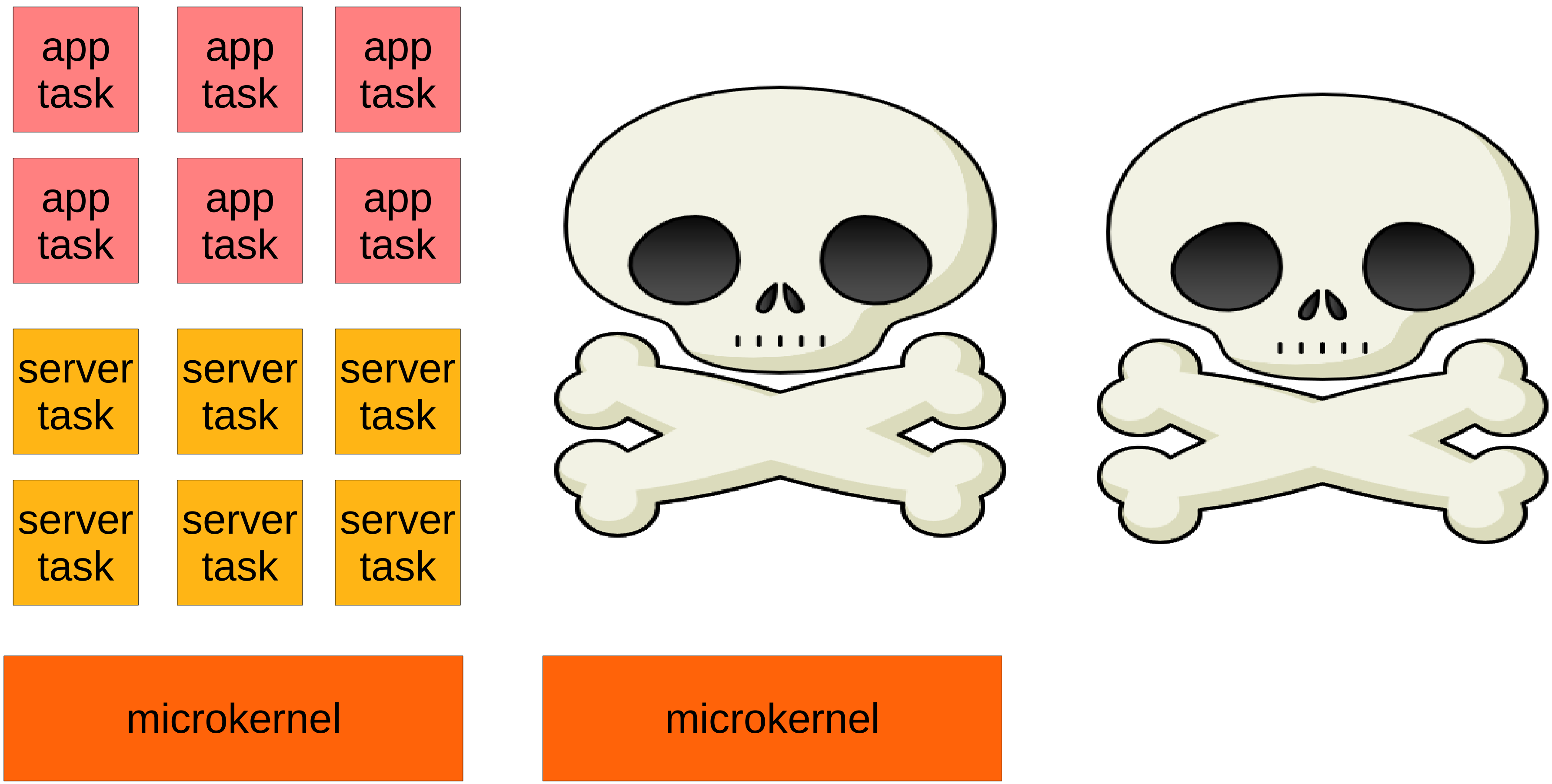

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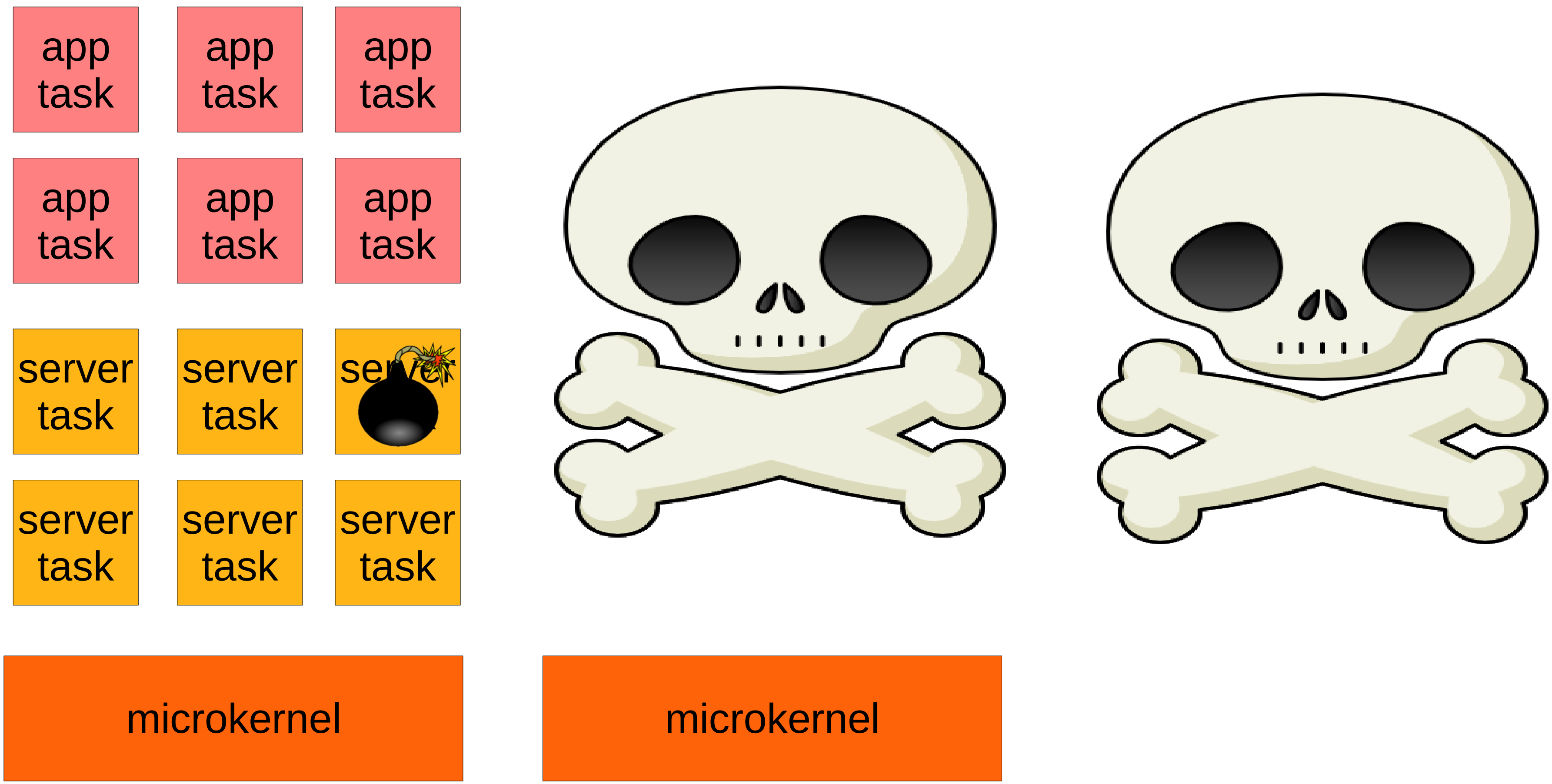

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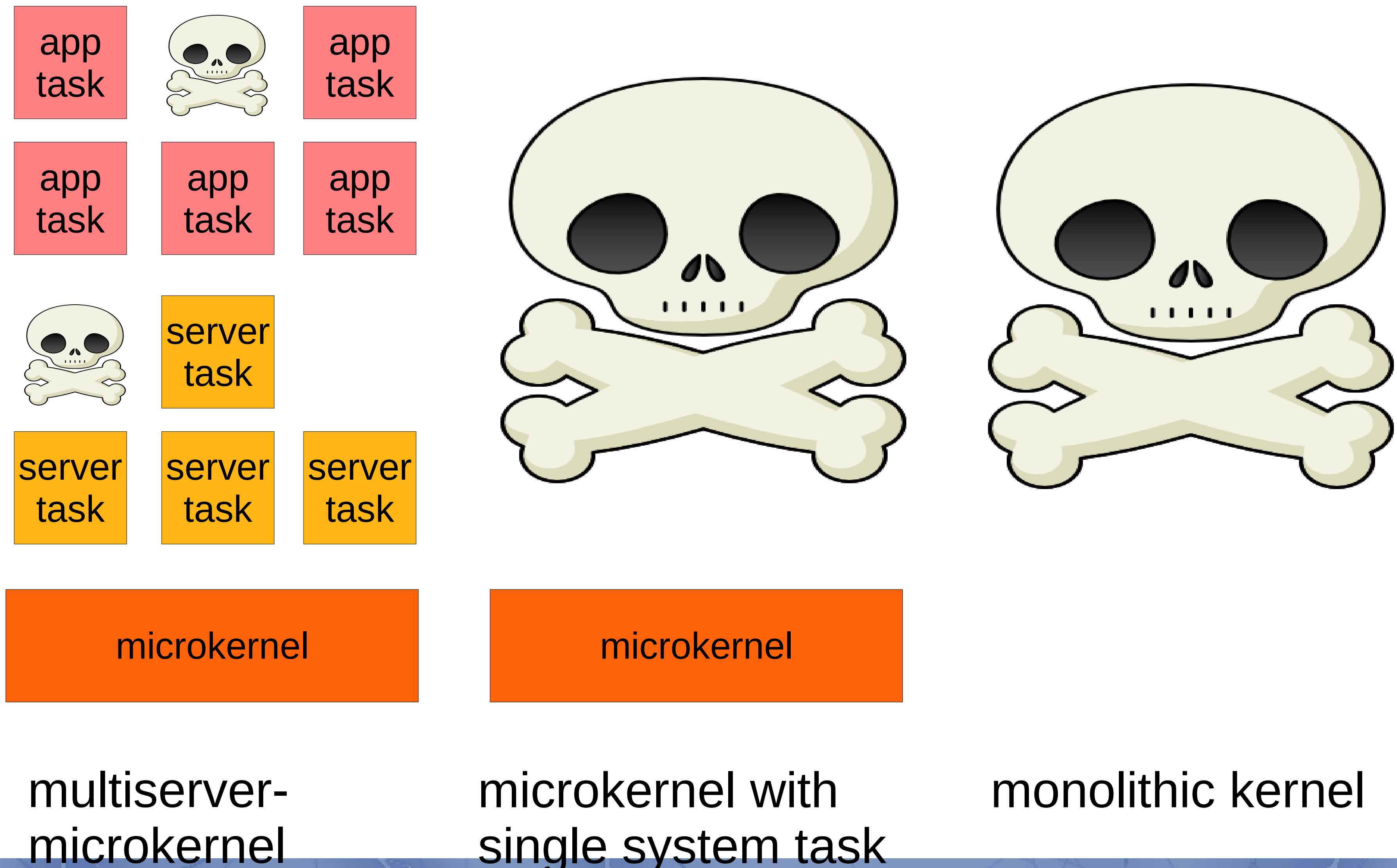

Pros and Cons Overview

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- Clean interface between servers
- Simpler components
- Flexibility in connecting components

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Cons

- Worse performance
- No cross-layer optimizations

Multiserver-Microkernel Examples

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http://hurd.gnu.org

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HelenOS
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Simplified HelenOS Architecture

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microkernel
SPARTAN

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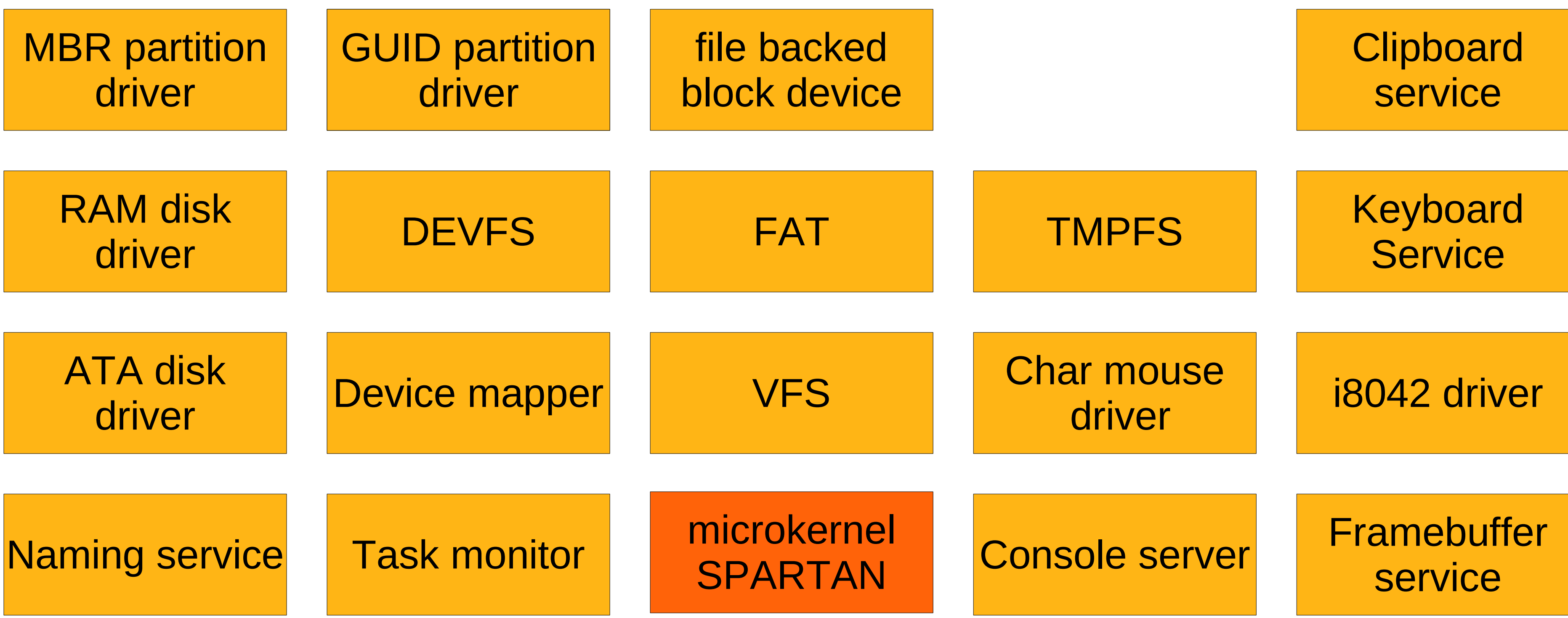

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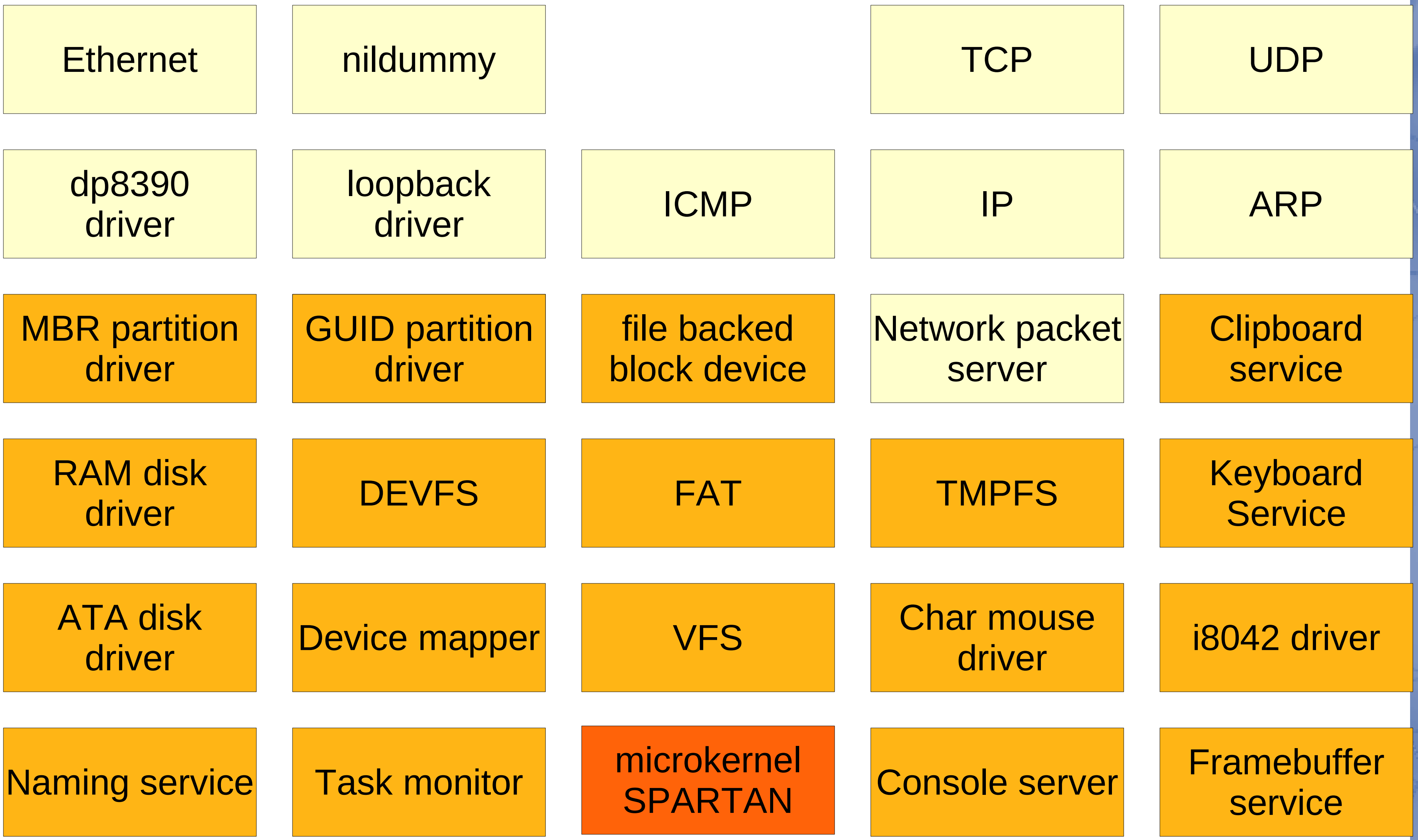

Simplified HelenOS Architecture

Ethernet	nildummy	Application	TCP	UDP
dp8390 driver	loopback driver	ICMP	IP	ARP
MBR partition driver	GUID partition driver	file backed block device	Network packet server	Clipboard service
RAM disk driver	DEVFS	FAT	TMPFS	Keyboard Service
ATA disk driver	Device mapper	VFS	Char mouse driver	i8042 driver
Naming service	Task monitor	microkernel SPARTAN	Console server	Framebuffer service

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- Some servers may even run in multiple instances
- All servers provide some services to other server tasks or applications; most servers require services from other servers
- Together these server tasks provide the services of the operating system

Making it all hold together (II)

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- Both the monolithic OS and the single system task microkernel OS deal only with one address space
- In a multiserver OS, the servers are in separate address spaces
- Message passing provided by the kernel
  - IPC

HelenOS IPC

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  - unusual metaphor of making phone calls and leaving a message in the answerbox
    - Asynchronous
- Number of communicating tasks can be 1, 2 or N
  - communicating with self
  - communicating with a peer
  - peer forwards the call to third party

HelenOS IPC (II)

- Message ~ Phone call
  - simple calls
  - combo calls

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- Simple calls
  - Six 32-bit / 64-bit words of payload
- Combo calls
  - memory sharing
  - large data block copying
  - tasks negotiate, kernel arbitrates

Life with IPC

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    - object oriented design

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Life with IPC (II)

- It also brings some problems
  - writing IPC by hand is tedious compared to mere function calls in monolithic designs
    - could be generated from some high level architecture description
    - all HelenOS IPC written by hand so far
  - it is difficult to implement non-trivial protocols using asynchronous IPC
    - callbacks and event loops
    - HelenOS has a framework for it

Asynchronous framework

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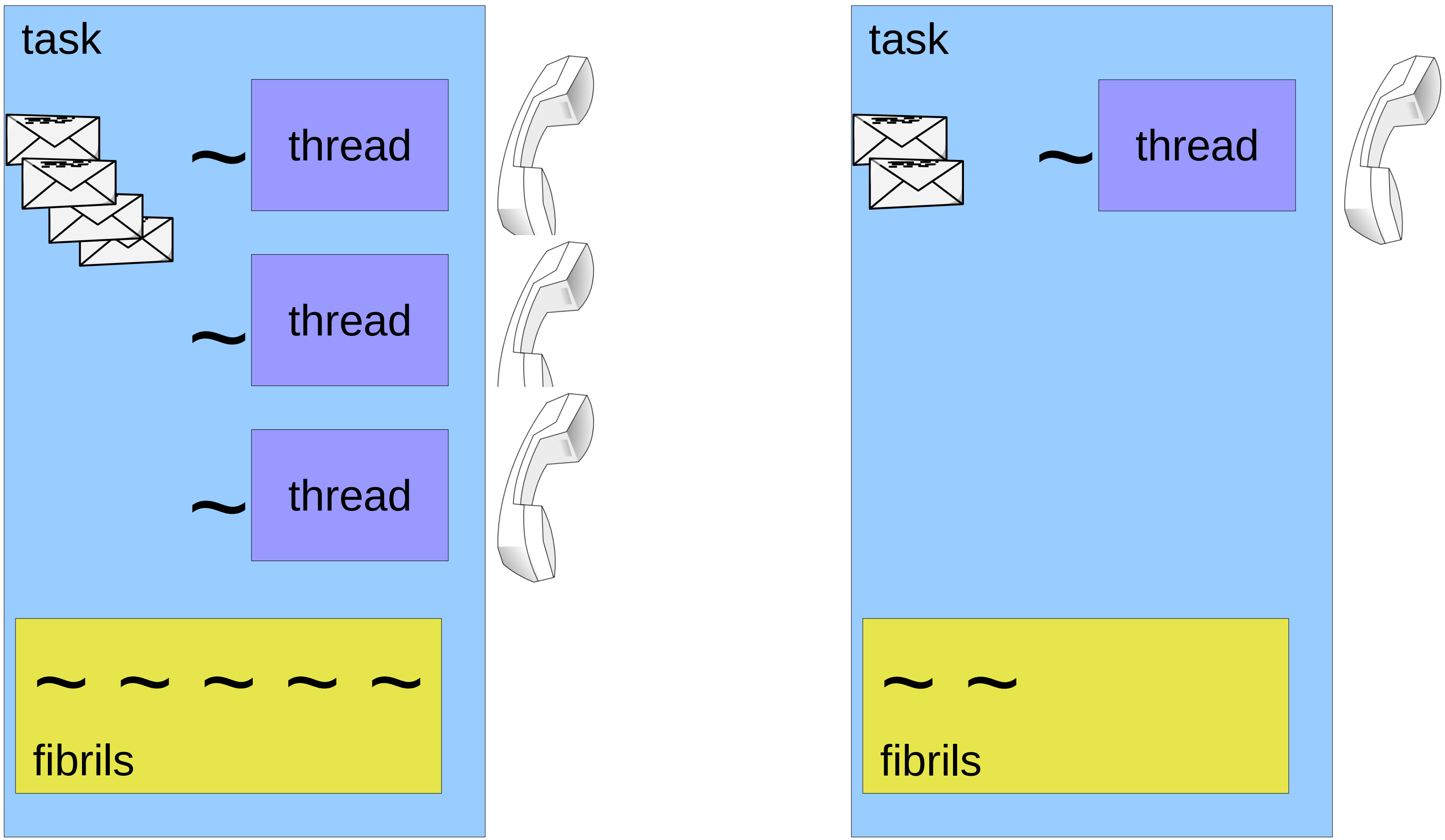
- Makes the asynchronous communication a pleasant experience
  - no event loops
  - no callbacks
- Introduces fibrils (userspace threads) to already multithreaded tasks
  - client's connection handled by a fibril in server
  - fibril can send asynchronous messages and wait for them later

Asynchronous framework (II)



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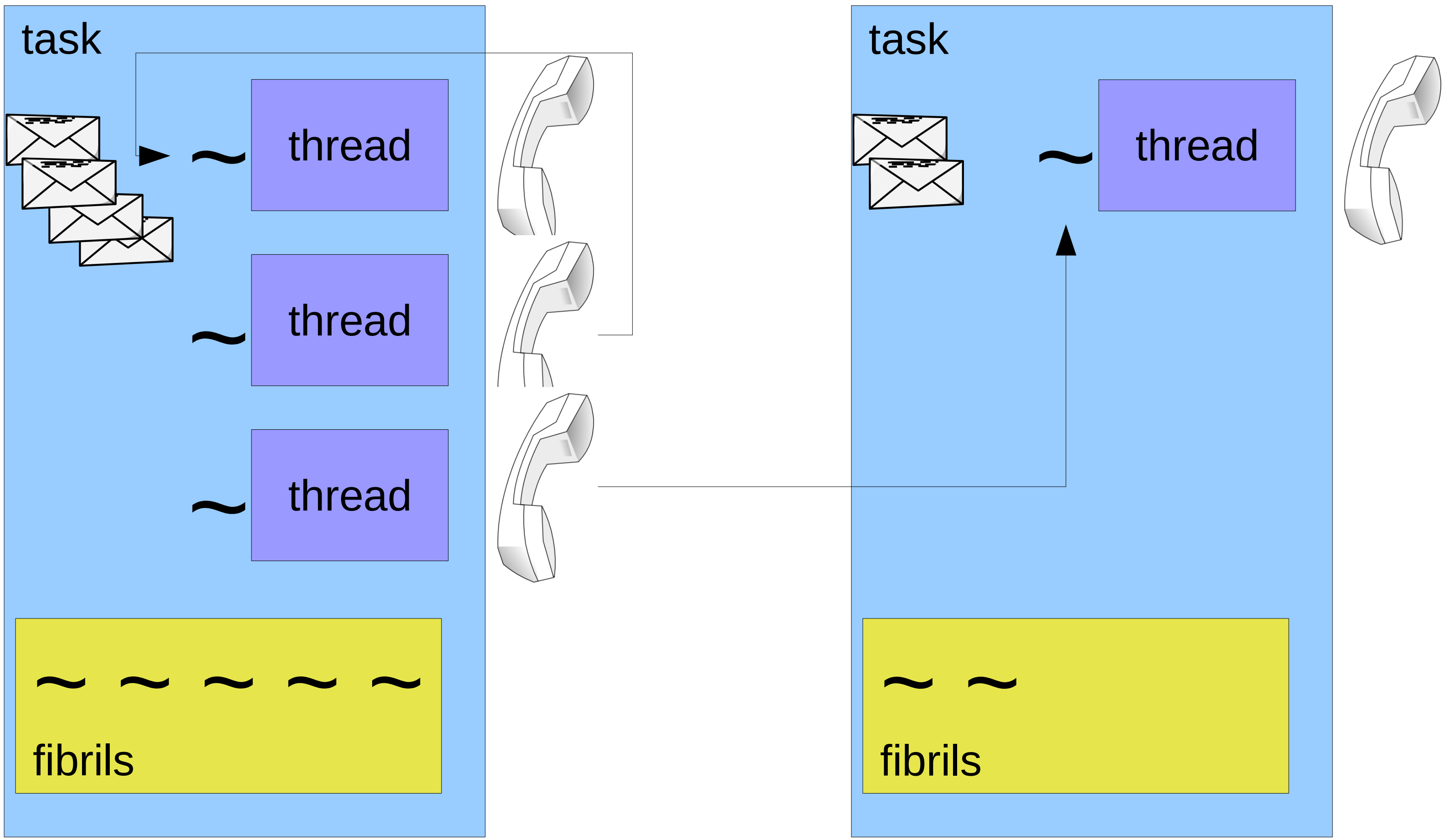

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- Send one message with *n* arguments
  - msgid = async_send_*n*(phone, *method*, ..., &answer)
- Wait for an answer to a sent message
  - async_wait_for(msgid, &retval0)

Using async framework (II)

- Send of *n* arguments and receive of *m* return values combined
  - retval0 = async_req_*n*_*m*(phone, method, ..., …)

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- Send of *n* arguments and receive of *m* return values combined
  - retval0 = async_req_*n*_*m*(phone, method, ..., …)
- Sharing memory
  - async_share_in/out_start(phone, ...)
  - async_share_in/out_receive(&callid, ...)
  - async_share_in/out_finalize(callid, ...)

Using async framework (III)

- Copying data
  - async_data_read/write_start(phone, ...)
  - async_data_read/write_receive(&callid, ...)
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Using async framework (III)

- Copying data
  - async_data_read/write_start(phone, ...)
  - async_data_read/write_receive(&callid, ...)
  - async_data_read/write_finalize(callid, …)
- Fibrils often need to be synchronized
  - Fibril synchronization primitives
    - Mutexes
    - Readers-Write locks
    - Condition variables

Code example

```
req = async_send_2(vfs_phone, VFS_IN_MOUNT, dev_handle, flags, NULL);
rc = async_data_write_start(vfs_phone, (void *) mpa, mpa_size);
if (rc != EOK) {
	...
}
rc = async_data_write_start(vfs_phone, (void *) opts, str_size(opts));
if (rc != EOK) {
	...
}
rc = async_data_write_start(vfs_phone, (void *) fs_name, str_size(fs_name));
if (rc != EOK) {
	...
}
/* Ask VFS whether it likes fs_name. */
rc = async_req_0_0(vfs_phone, IPC_M_PING);
if (rc != EOK) {
	...
}
async_wait_for(req, &rc);
```

Code example (II)

```
if (read)
        res = async_data_read_receive(&callid, NULL);
else
        res = async_data_write_receive(&callid, NULL);
if (read)
        fibril_rwlock_read_lock(&file->node->contents_rwlock);
else
        fibril_rwlock_write_lock(&file->node->contents_rwlock);
msg = async_send_3(fs_phone, read ? VFS_OUT_READ : VFS_OUT_WRITE,
    file->node->dev_handle, file->node->index, file->pos, &answer);
ipc_forward_fast(callid, fs_phone, 0, 0, 0, IPC_FF_ROUTE_FROM_ME);
async_wait_for(msg, &rc);
if (read)
        fibril_rwlock_read_unlock(&file->node->contents_rwlock);
else
        fibril_rwlock_write_unlock(&file->node->contents_rwlock);
ipc_answer_1(rid, rc, bytes);
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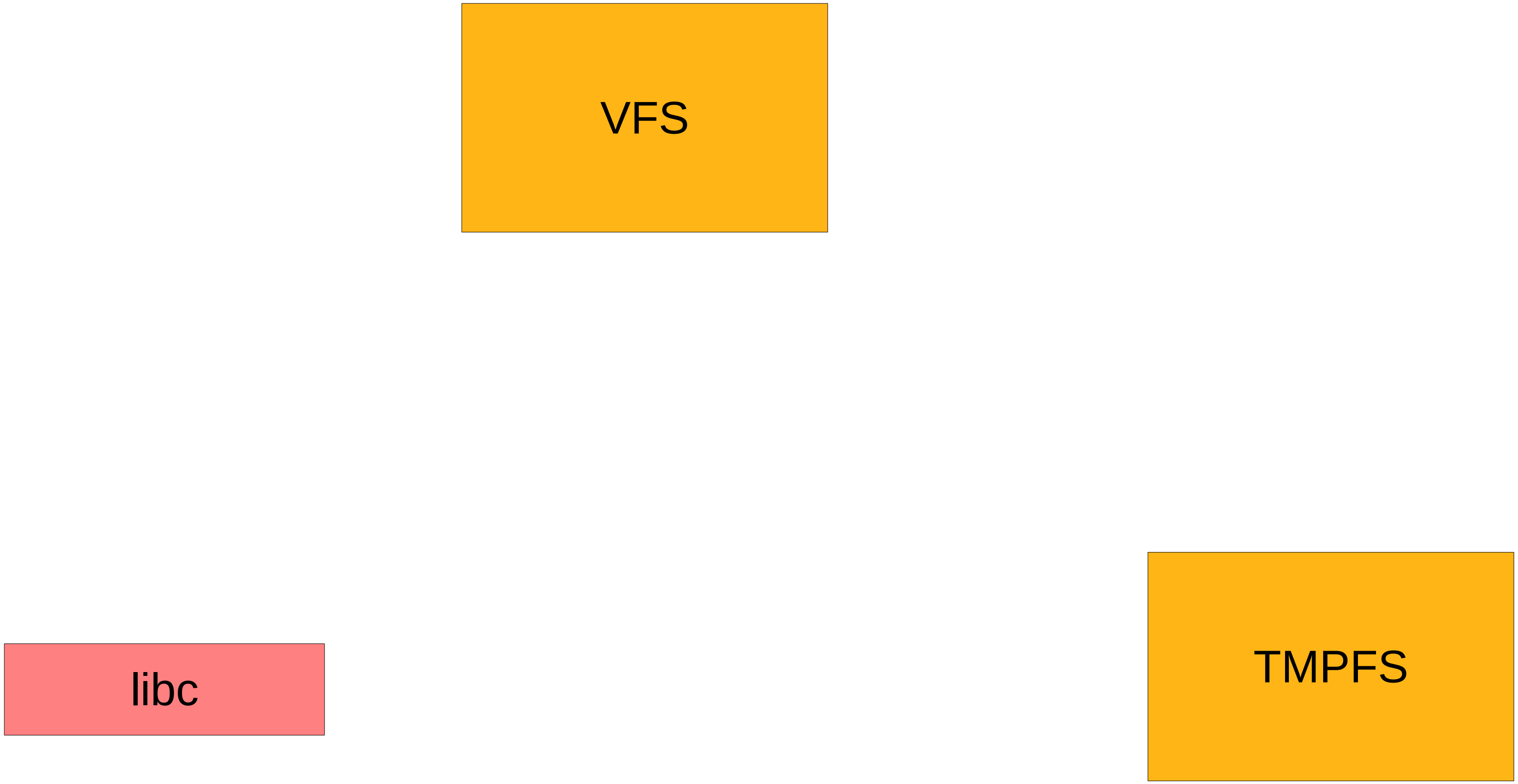

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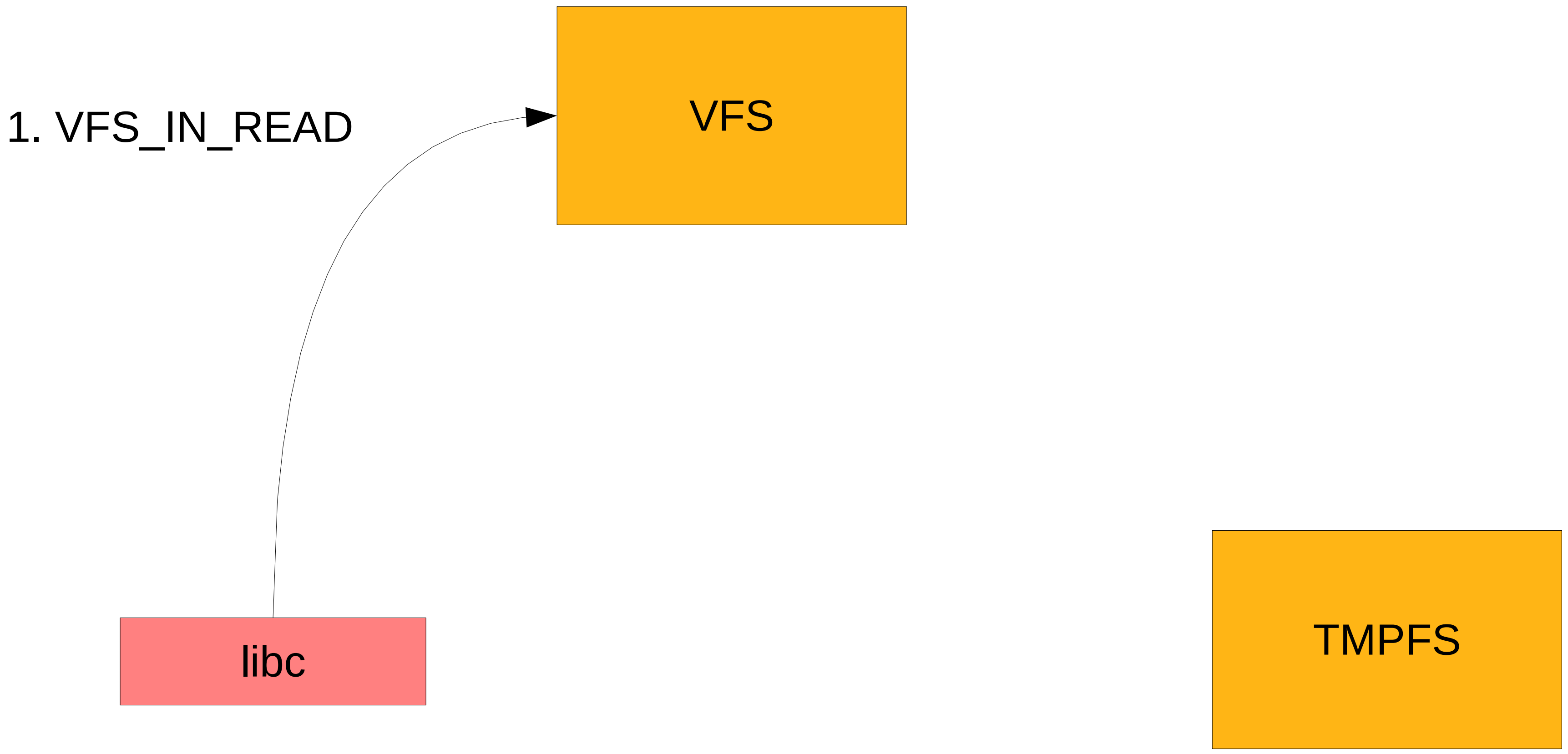

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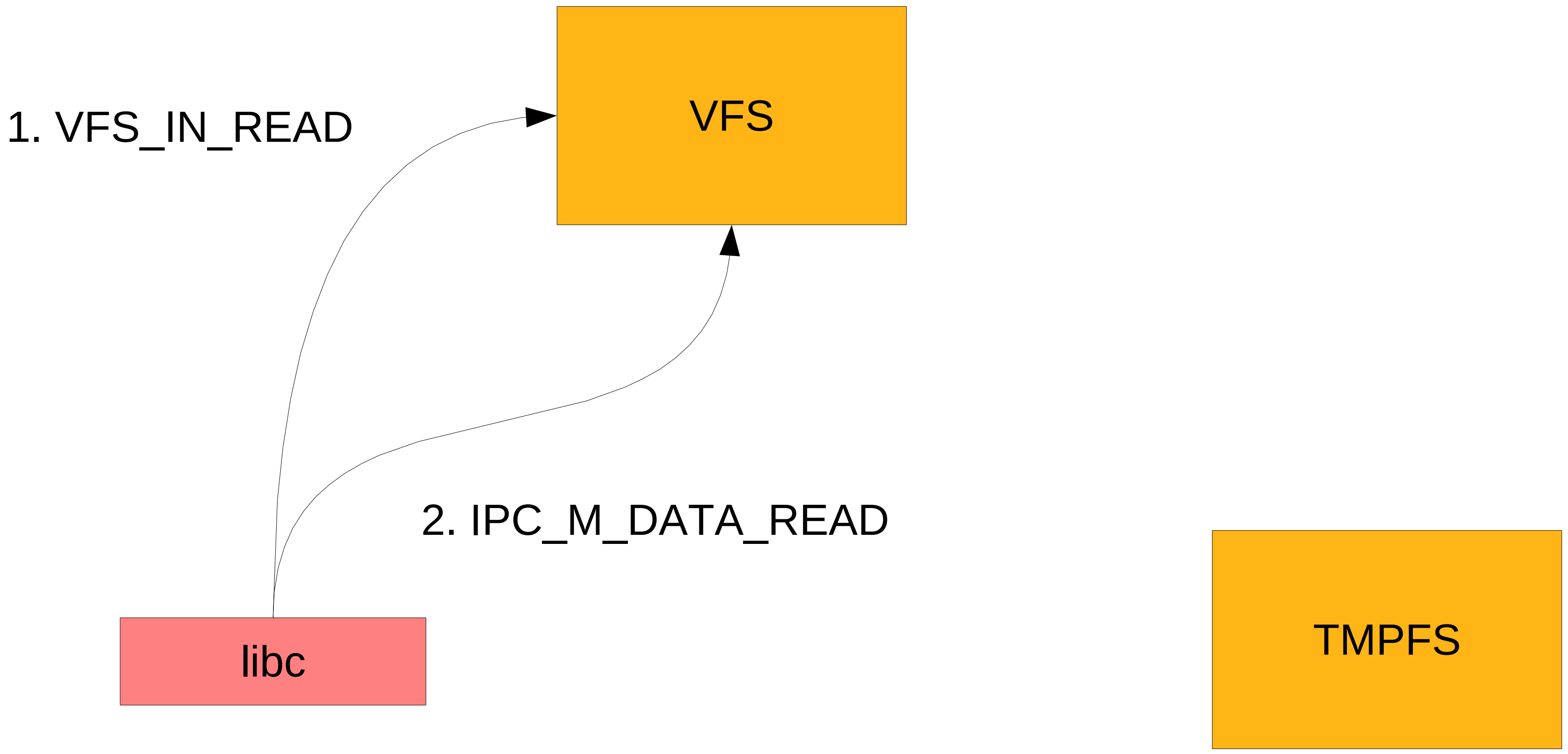

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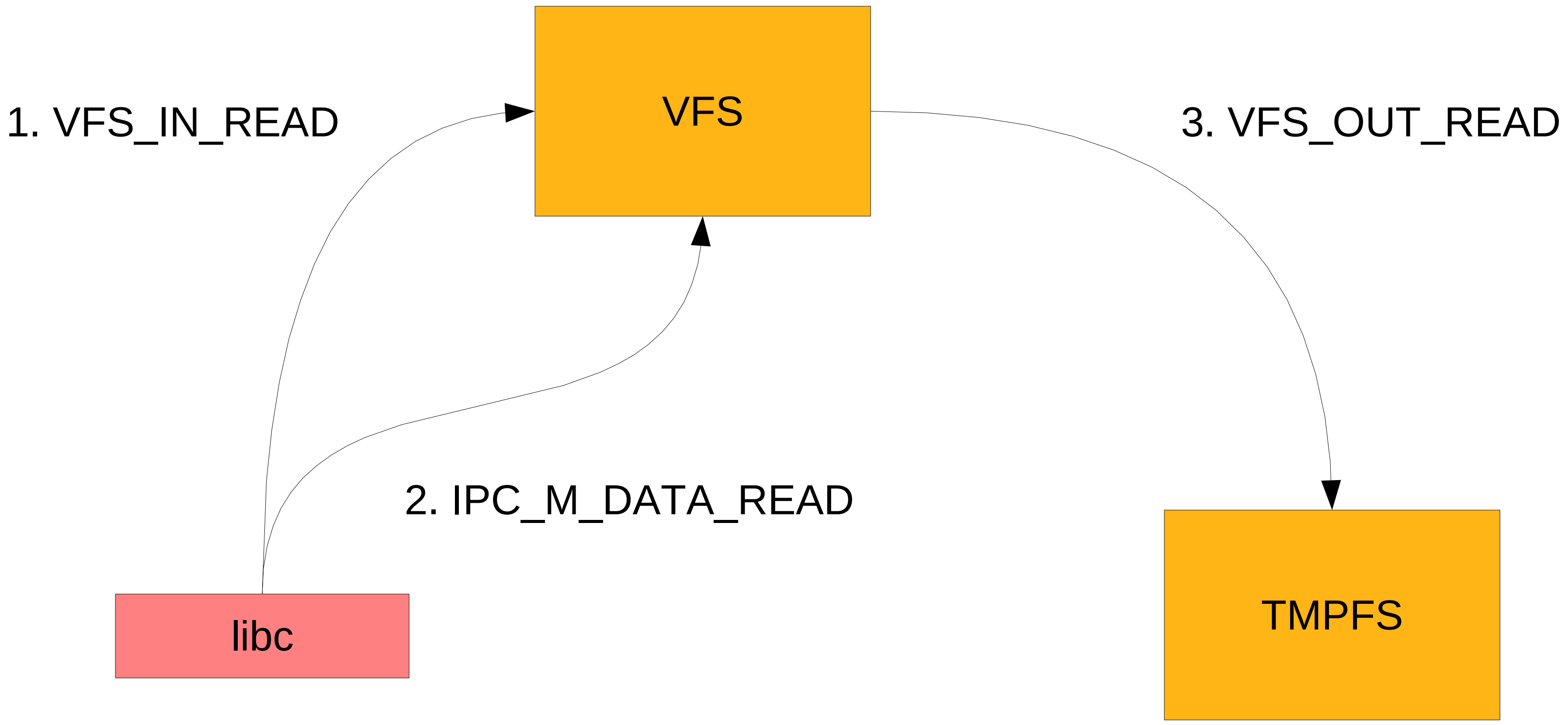

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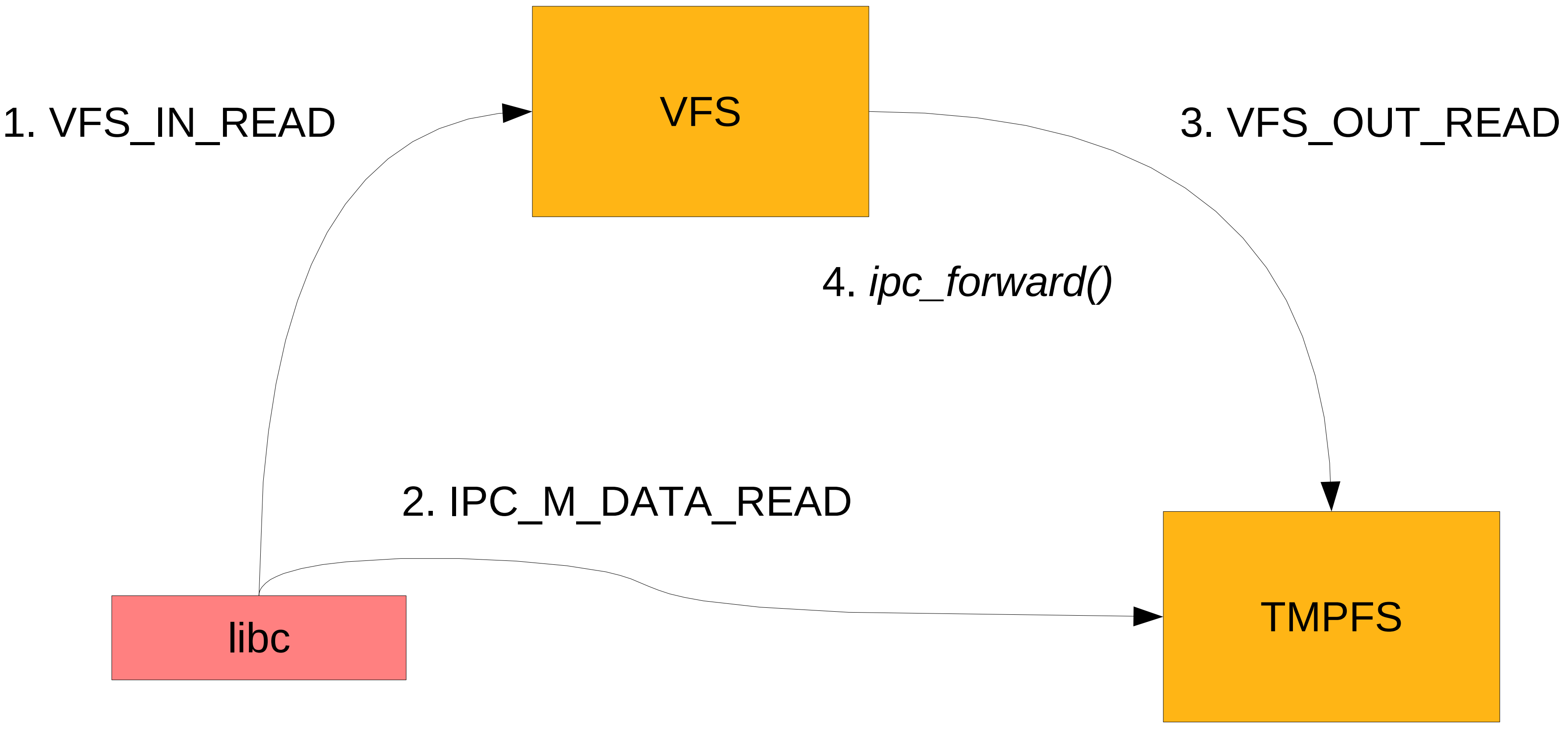

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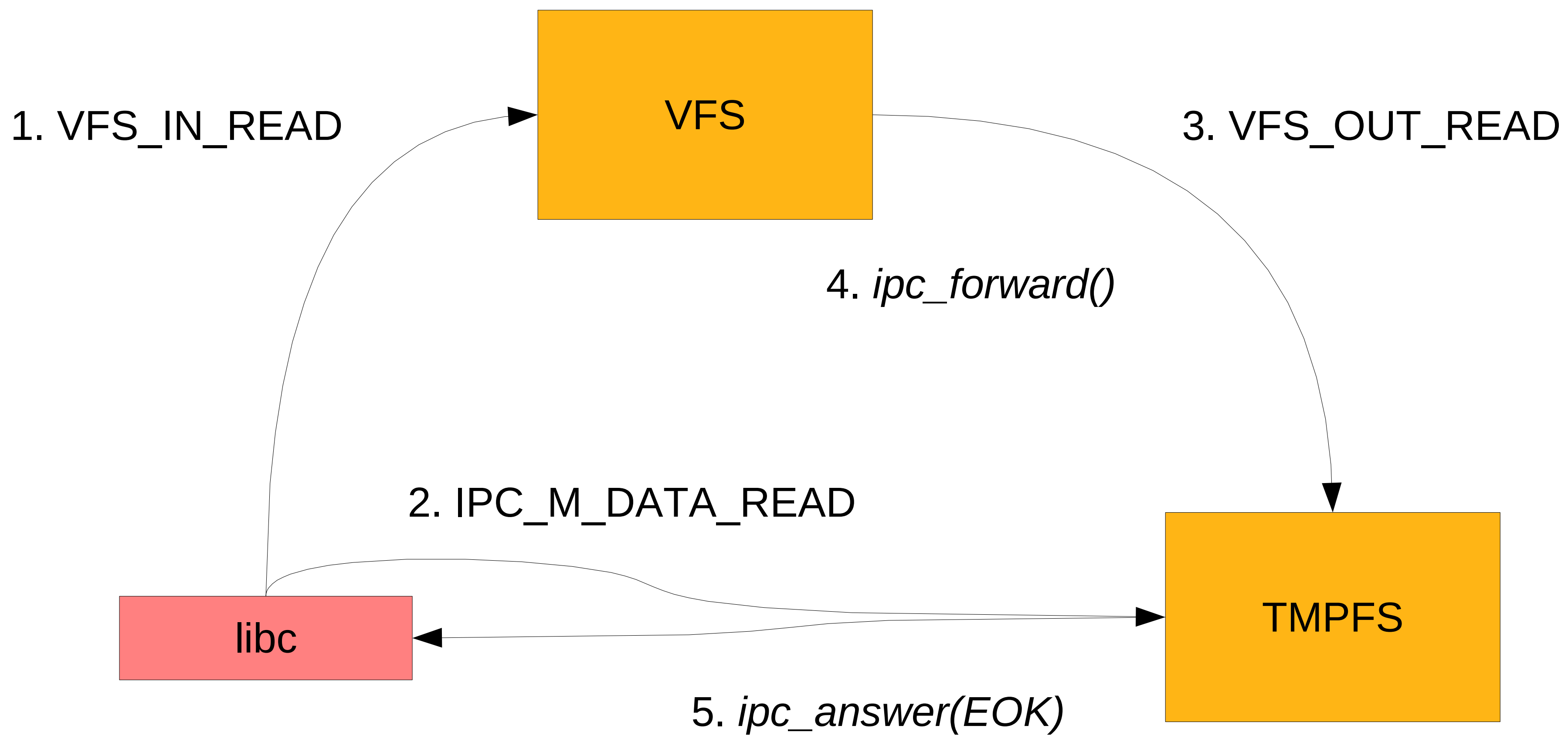

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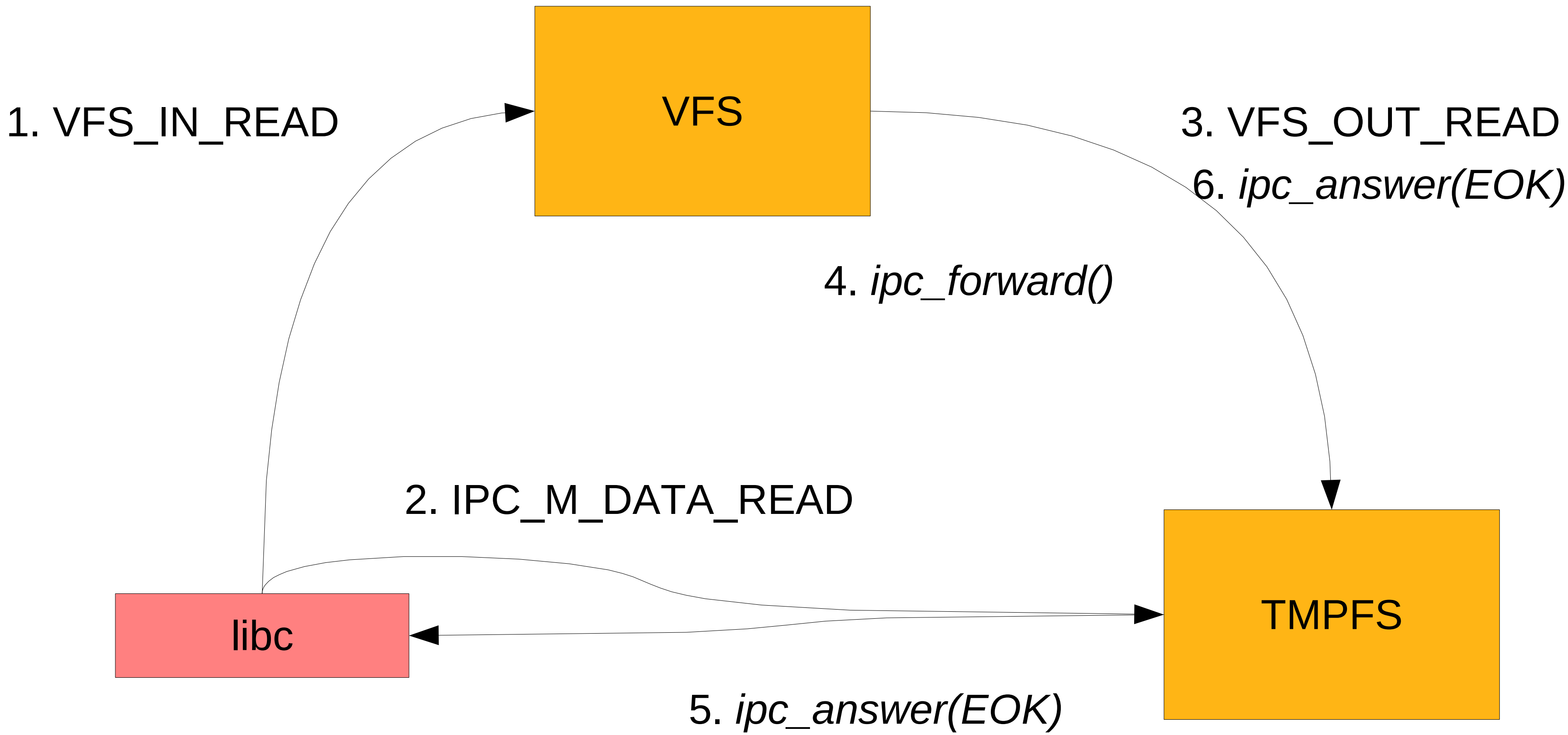

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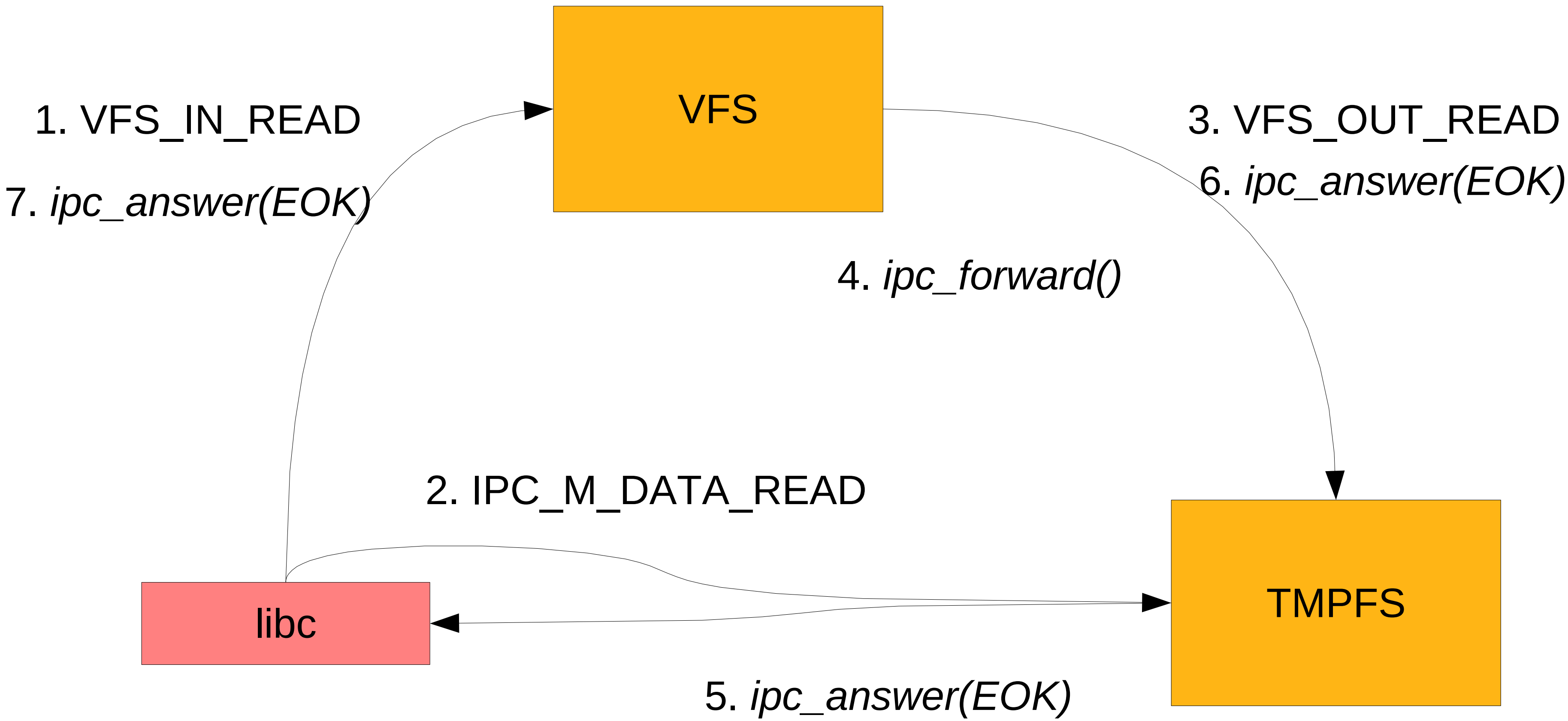

Demo

Questions?

www.helenos.org

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