Using Modern C++ to Revive an Old Design

JODY HAGINS

MAYSTREET

CppCon 2022

Using Modern C++ to Revive and Old Design

AKA: Coupling and Cohesion are Guiding Lights

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The Holy Grail

Low Coupling, High Cohesion, Composable, Testable, Reusable, Functional, Modular, Easy to Use, Easy to Change, High Throughput, Low Latency, Optimal Code Generation: Pick All of Them!

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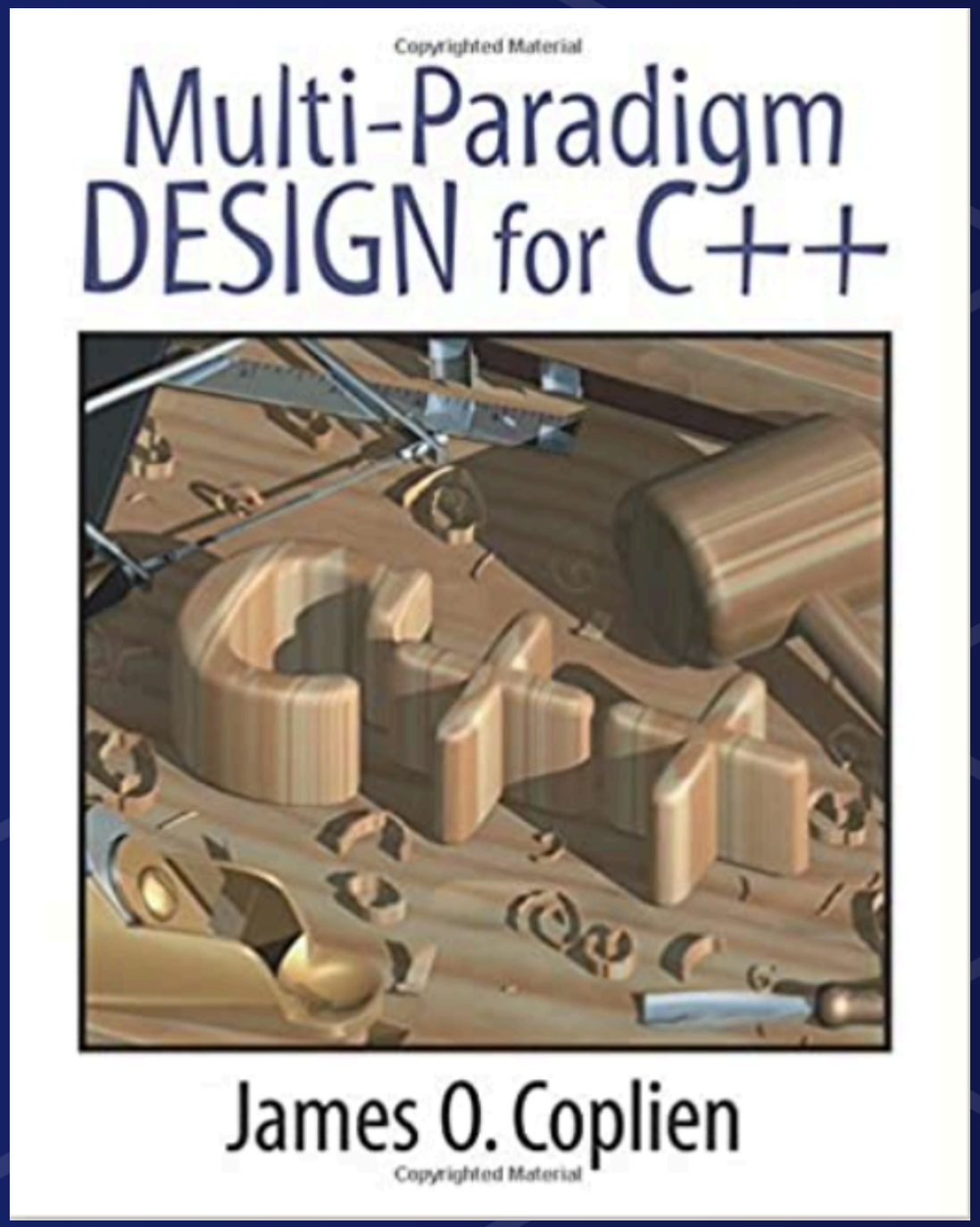
C++ Design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Multi-Paradigm
DESIGN for C++
James O. Coplien
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Coupling vs. Cohesion

"One goal of design is to minimize coupling between parts and to maximize cohesion within them."

Multi-Paradigm Design for C++ *James Coplien*

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Coupling vs. Cohesion

CSE 403 - Washington University

Coupling vs. Cohesion

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An indication of the strength of interconnections between program units.

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Modules are independent if they can function completely without the presence of the other.

Cohesion

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A component should implement a single logical function or single logical entity.

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All the parts should contribute to the implementation.

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An indication of the strength of interconnections between program units.

Cohesion is how much one part of a code base forms an atomic program unit

Coupling is how much a single program unit depends upon other program units

Simplified Example

```
Result
SomeClass::
process_packet(Packet const & packet)
{
    // Packet processing code
}
```

Can You Say Code Review?

```
Result
SomeClass::
process_packet(Packet const & packet)
{
    launch_rocket(
        global_rocket_launcher,
        random_coordinates());
    // Packet processing code
}
```

Less Scary

```
Result
SomeClass::
process_packet(Packet const & packet)
{
    if (Header(packet).is_compressed()) {
        return process_packet(uncompress(packet));
    }
    // packet processing code
}
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More or Less Scary

```
Result
SomeClass::
process_packet(Packet const & packet)
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    if (packet.timestamp() >= compression_timestamp &&
        Header(packet).is_compressed())
    {
        return process_packet(uncompress(packet));
    }
    // packet processing code
}
```

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The code block is the program unit that can create both the greatest coupling and the least cohesion.

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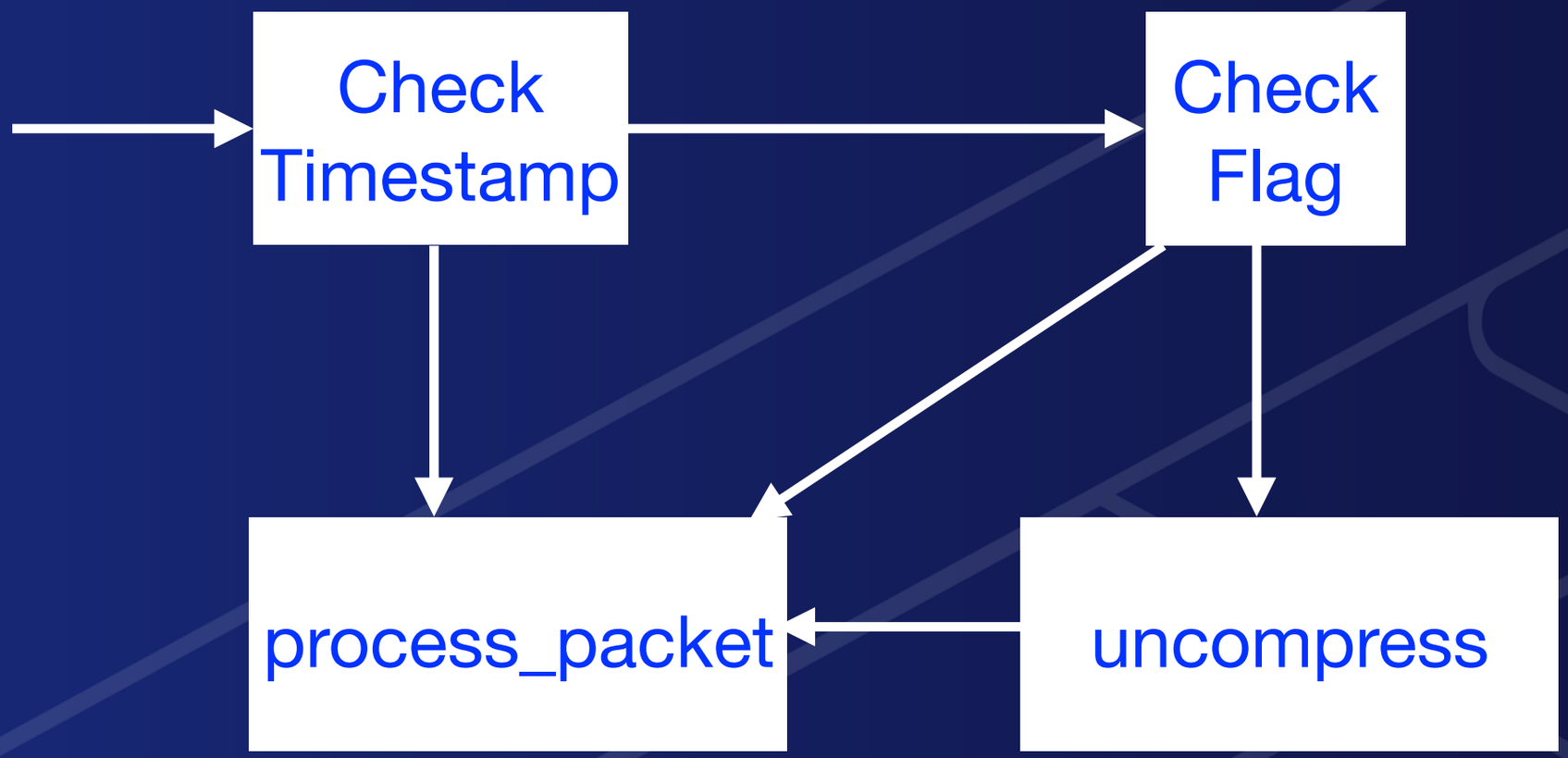
The code block is the program unit that can create both the greatest coupling and the least cohesion.

Coupling vs. Cohesion

Compose small, cohesive program units



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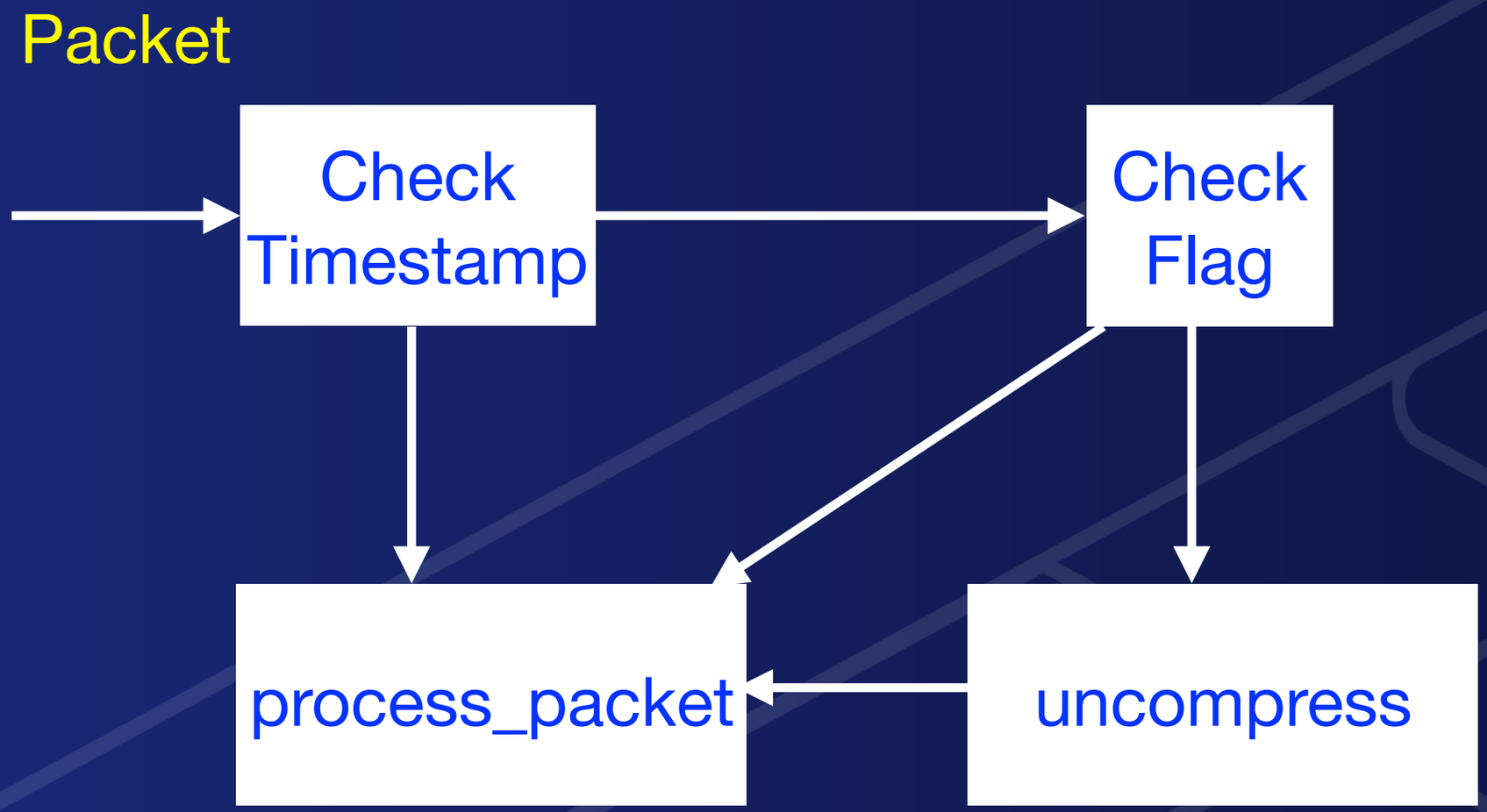

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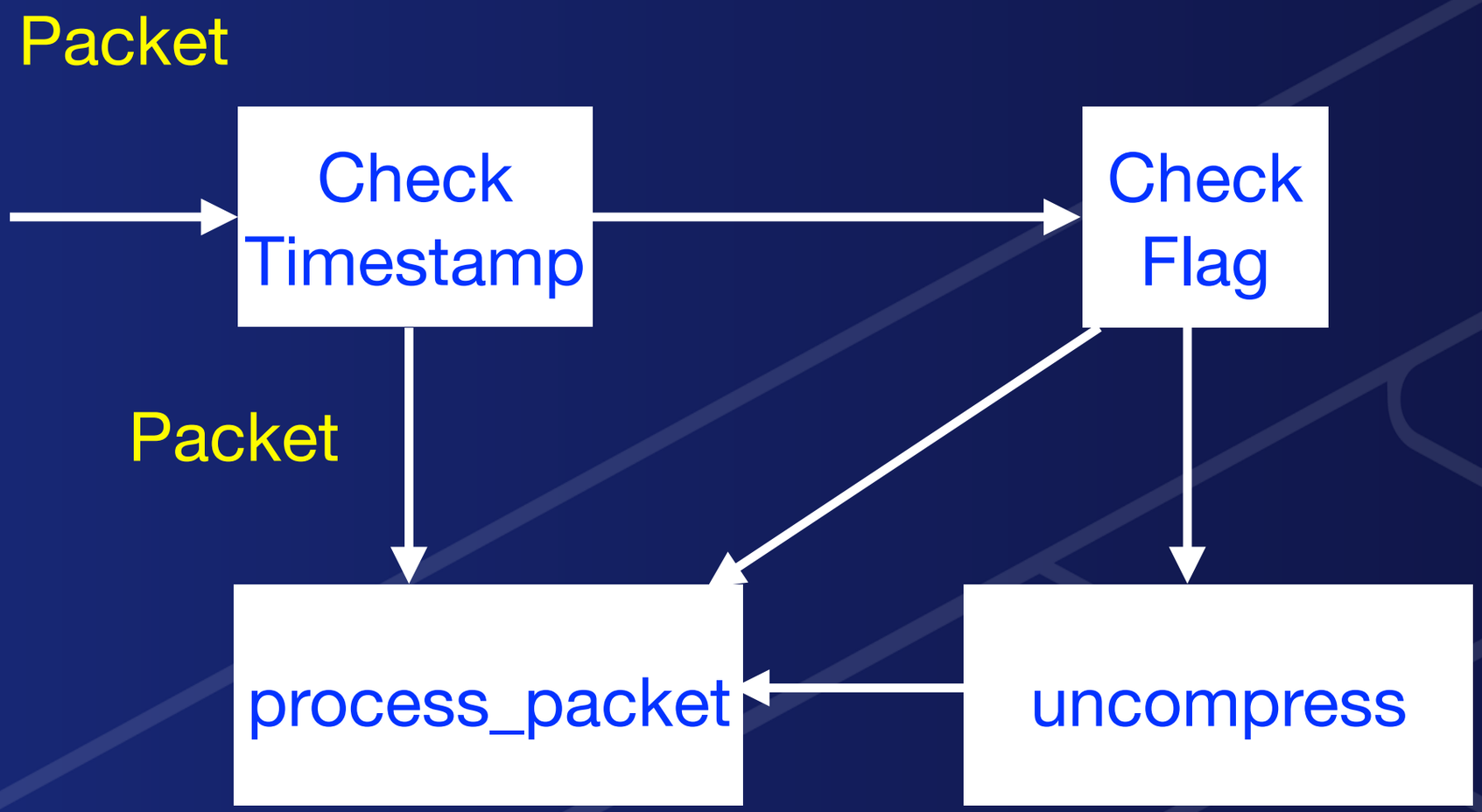

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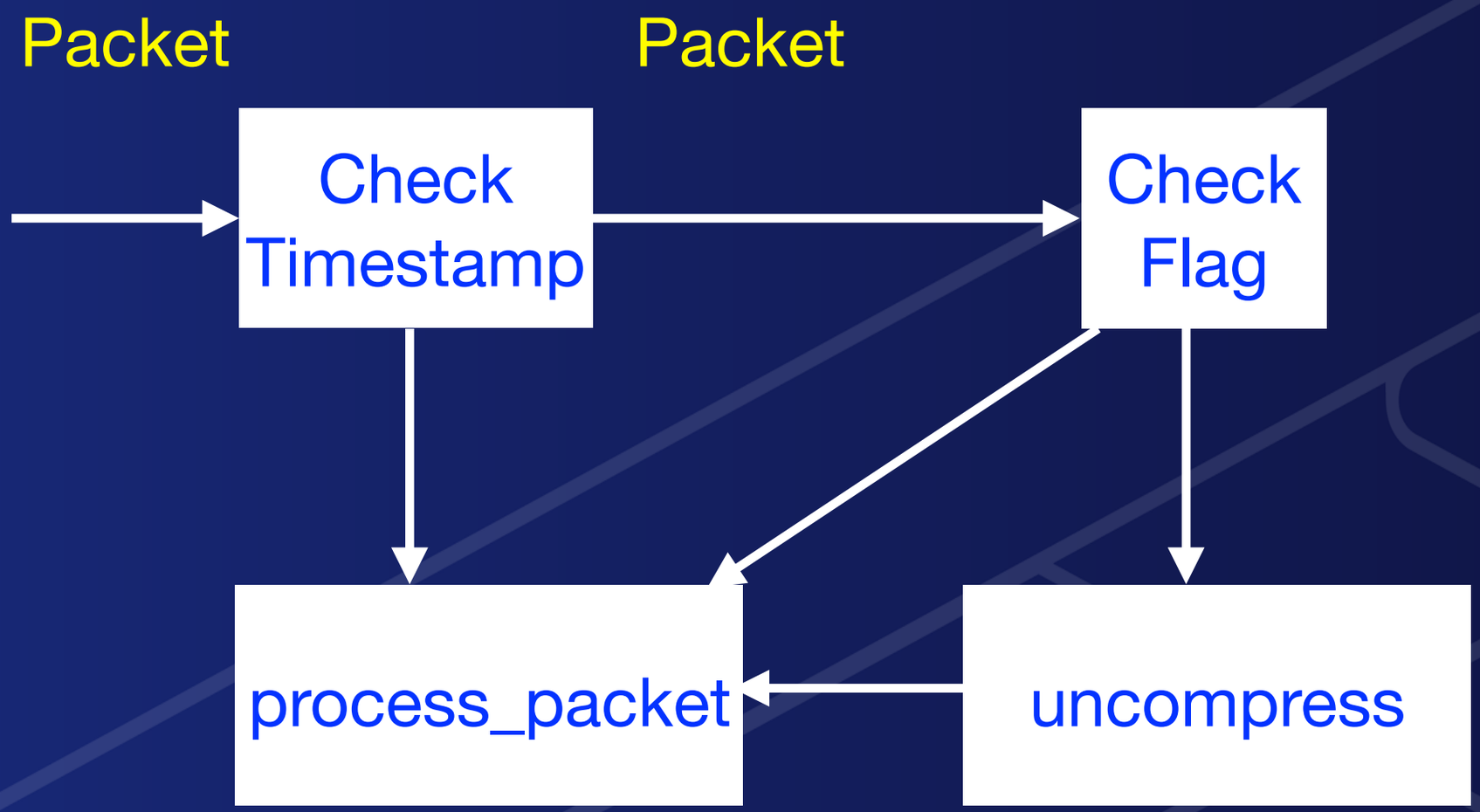

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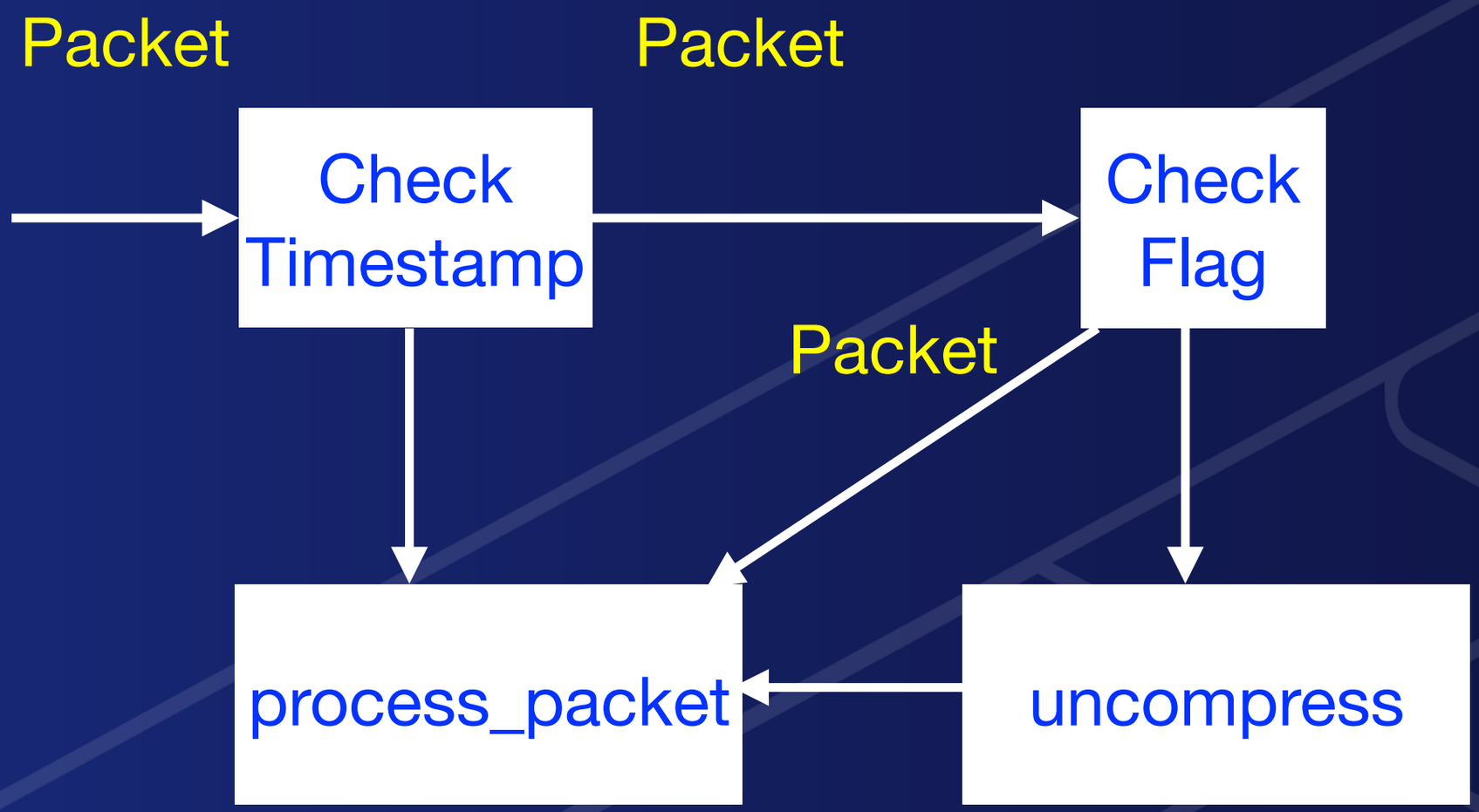

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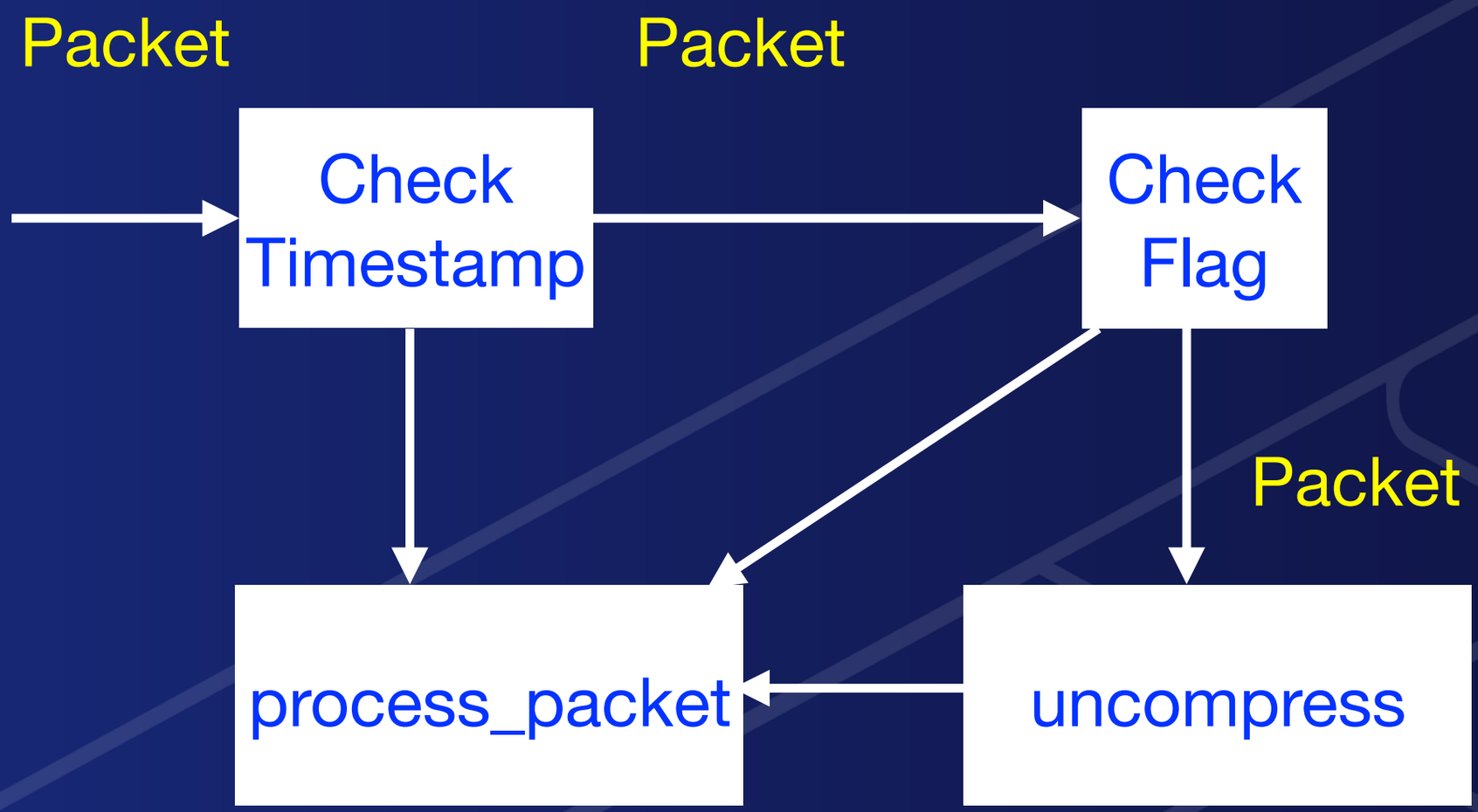

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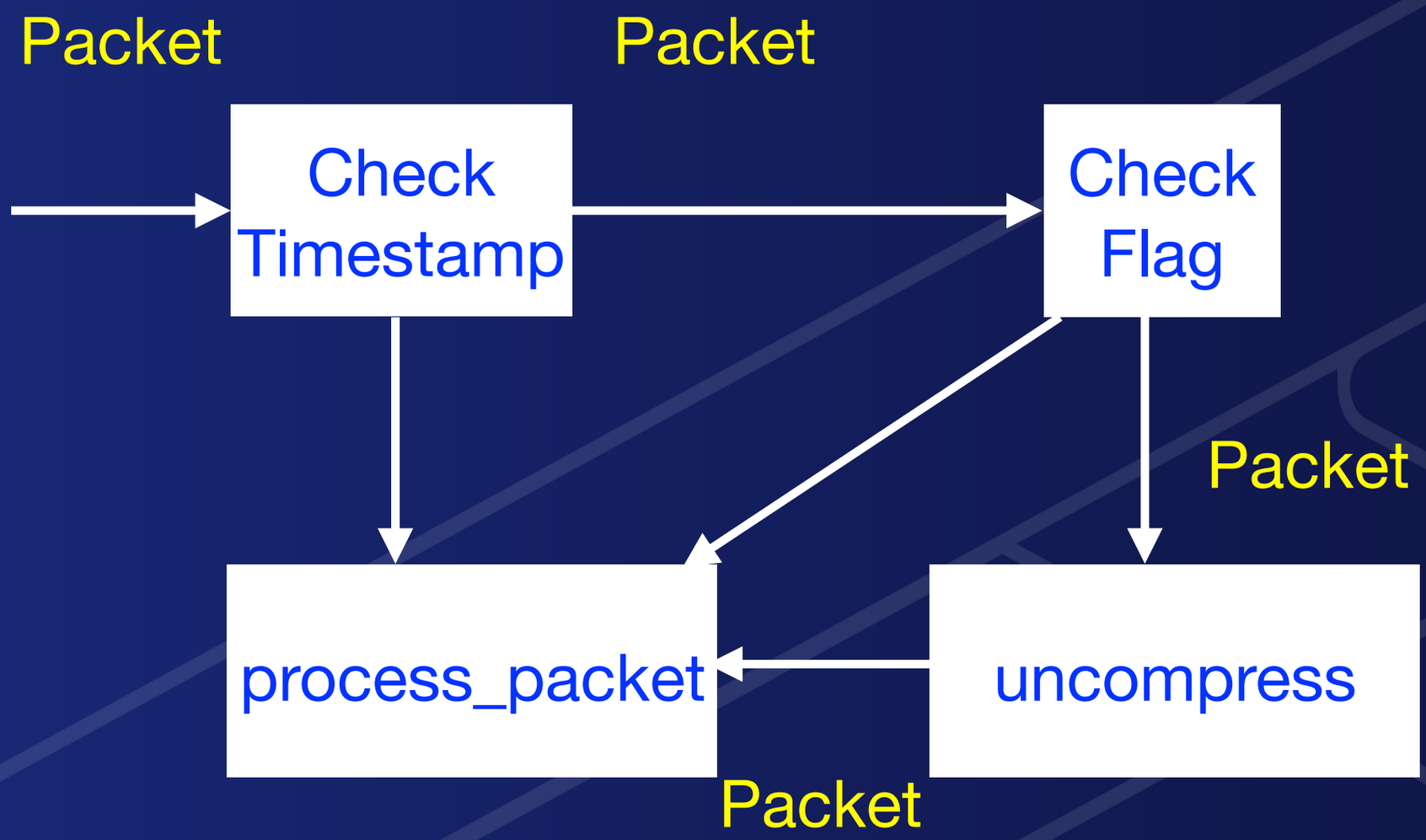

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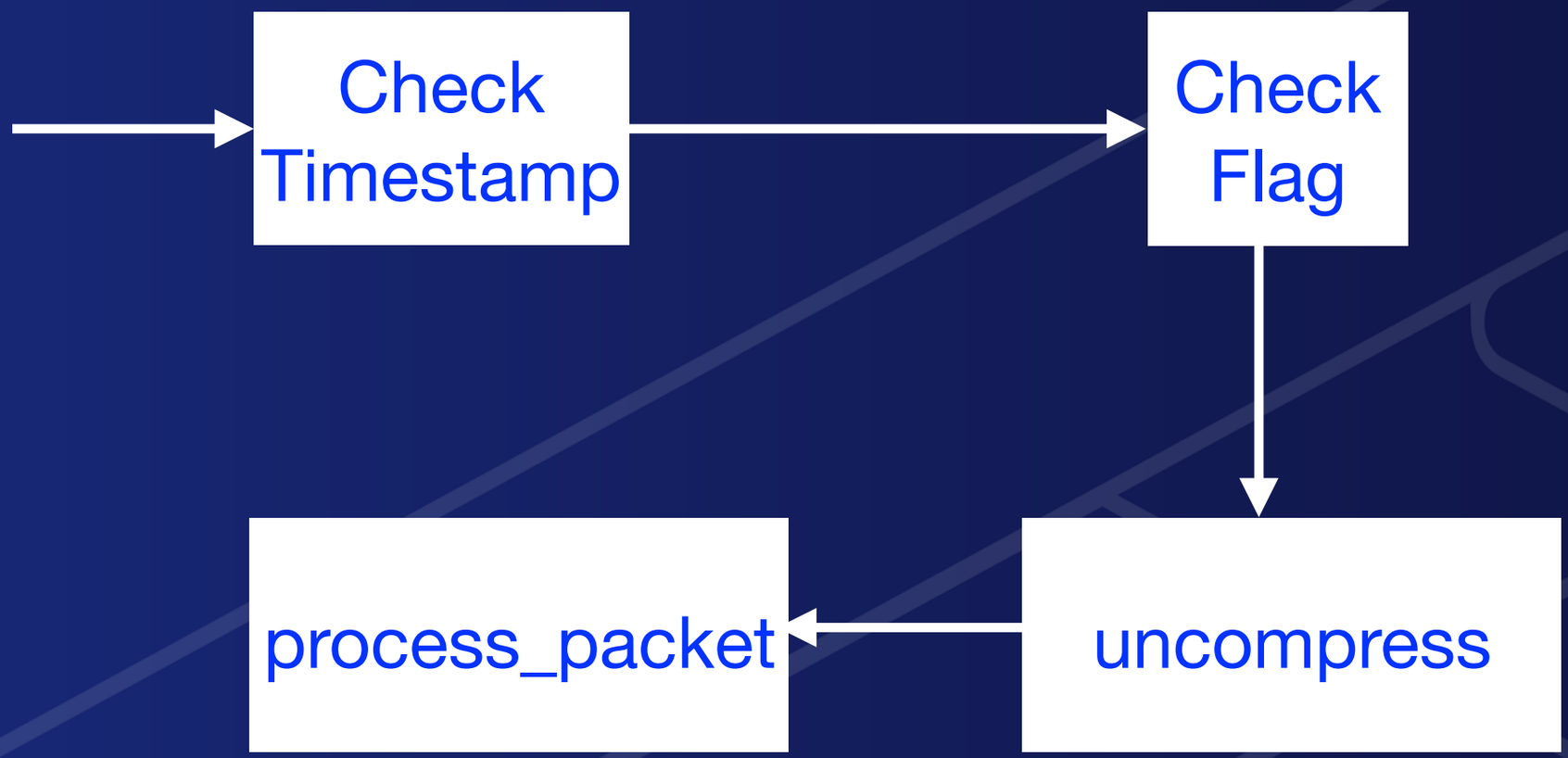

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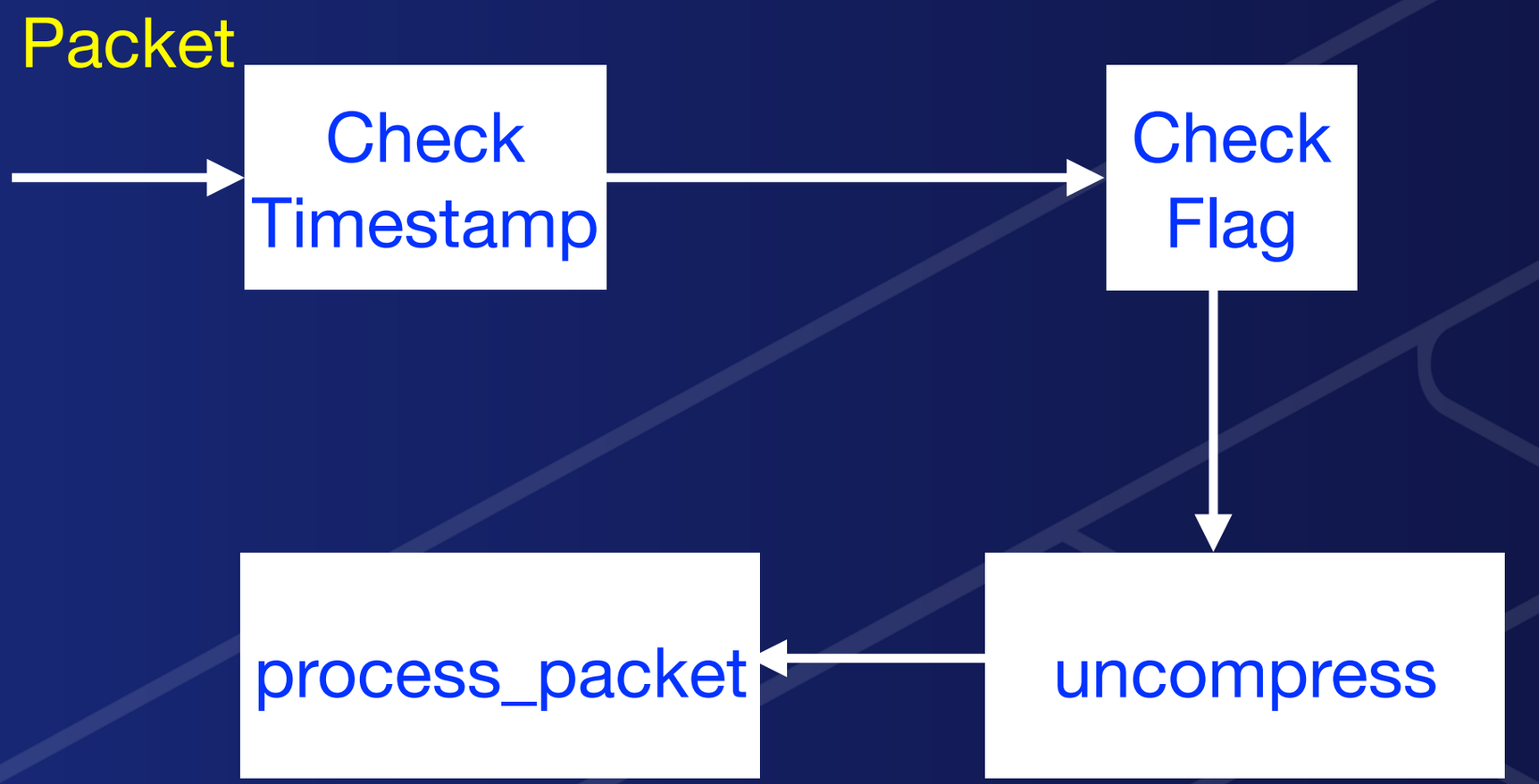

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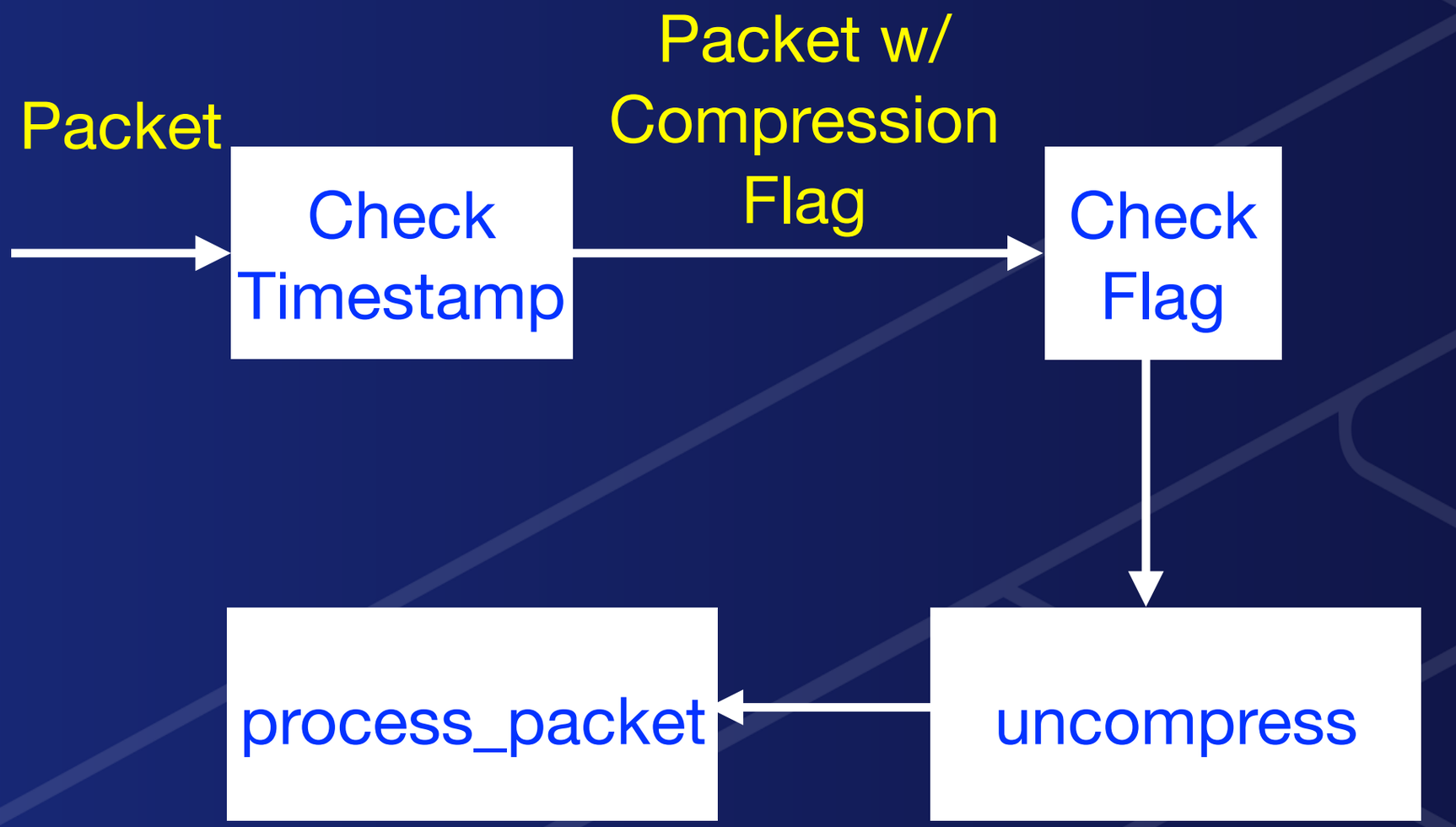

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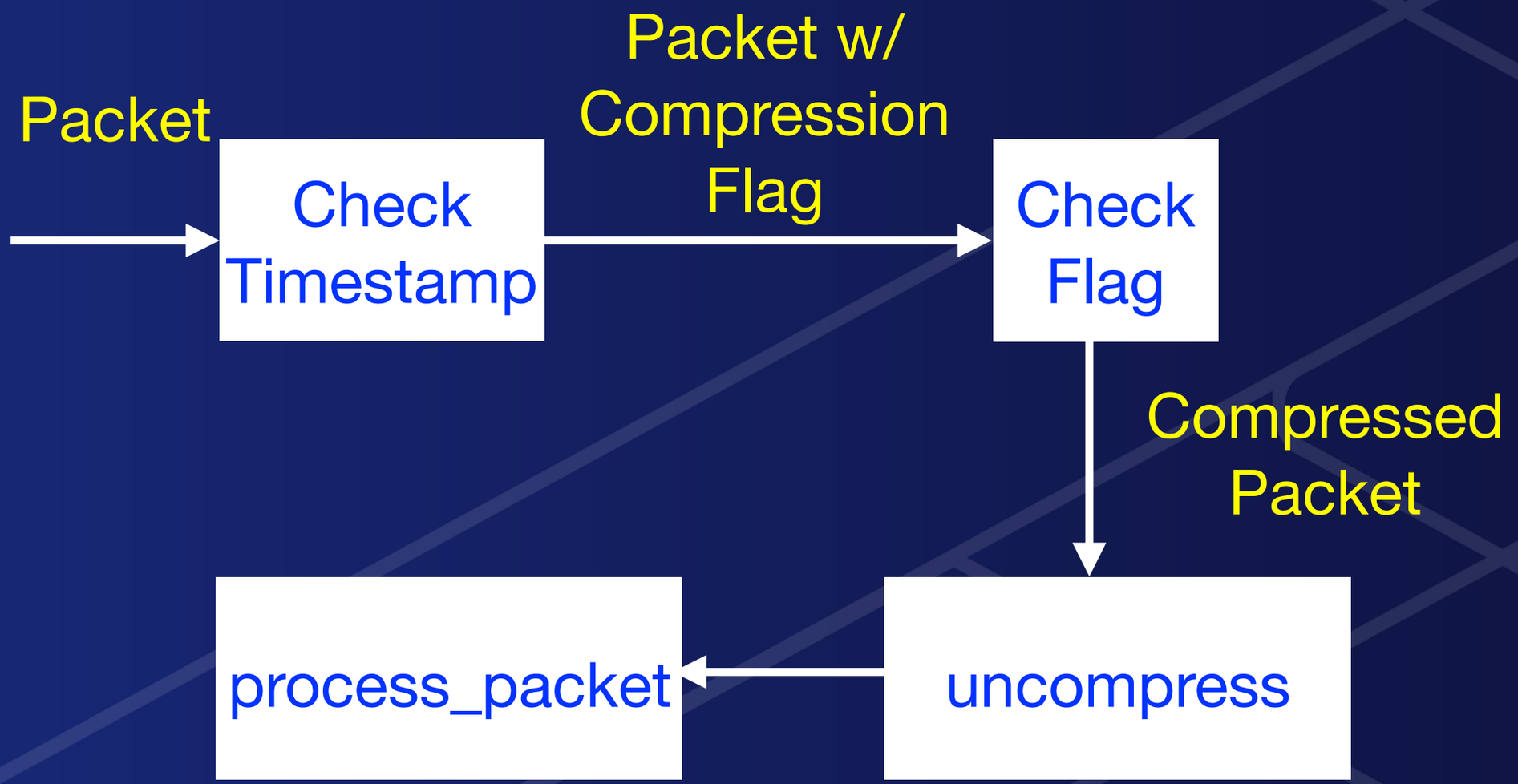

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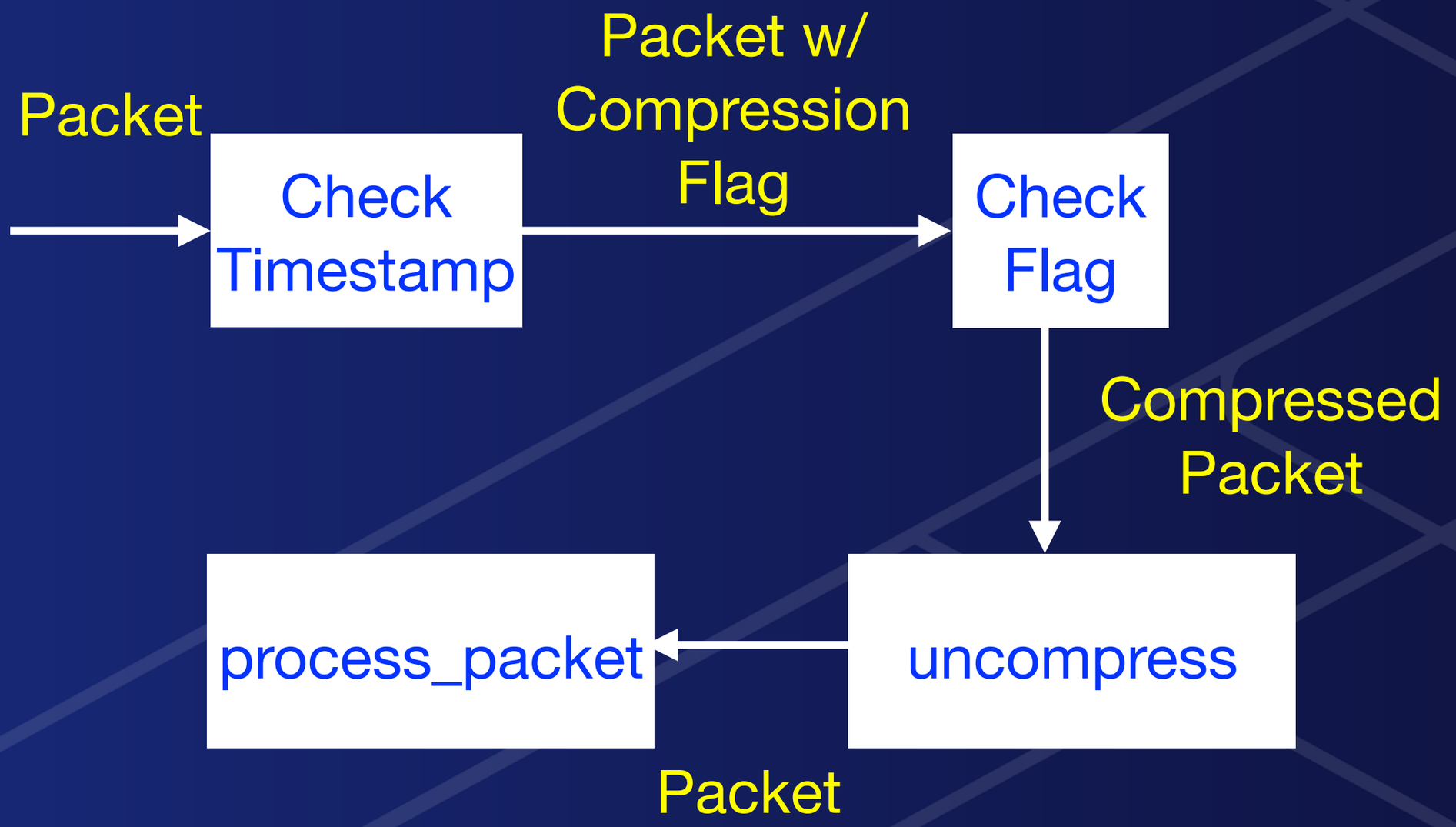

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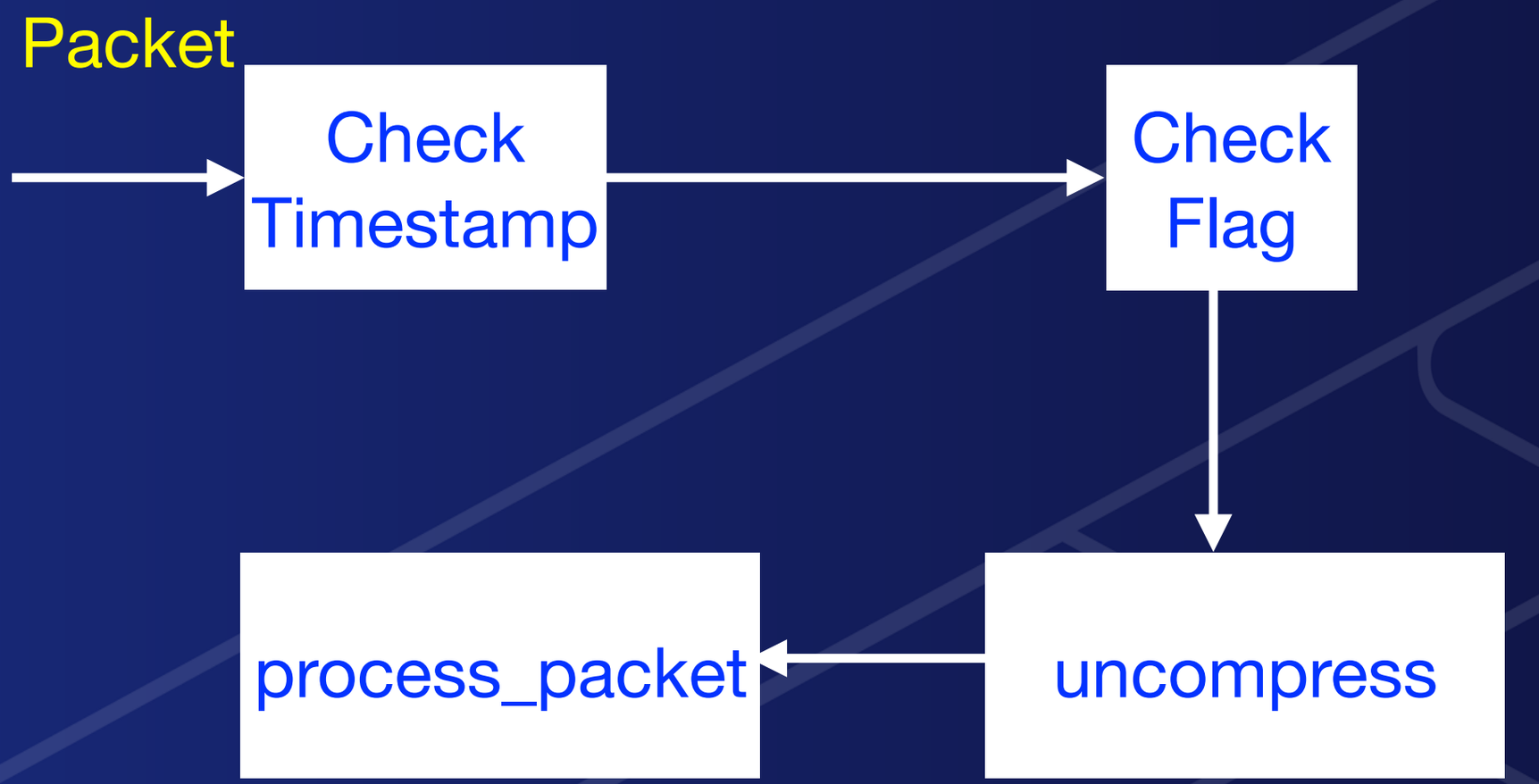

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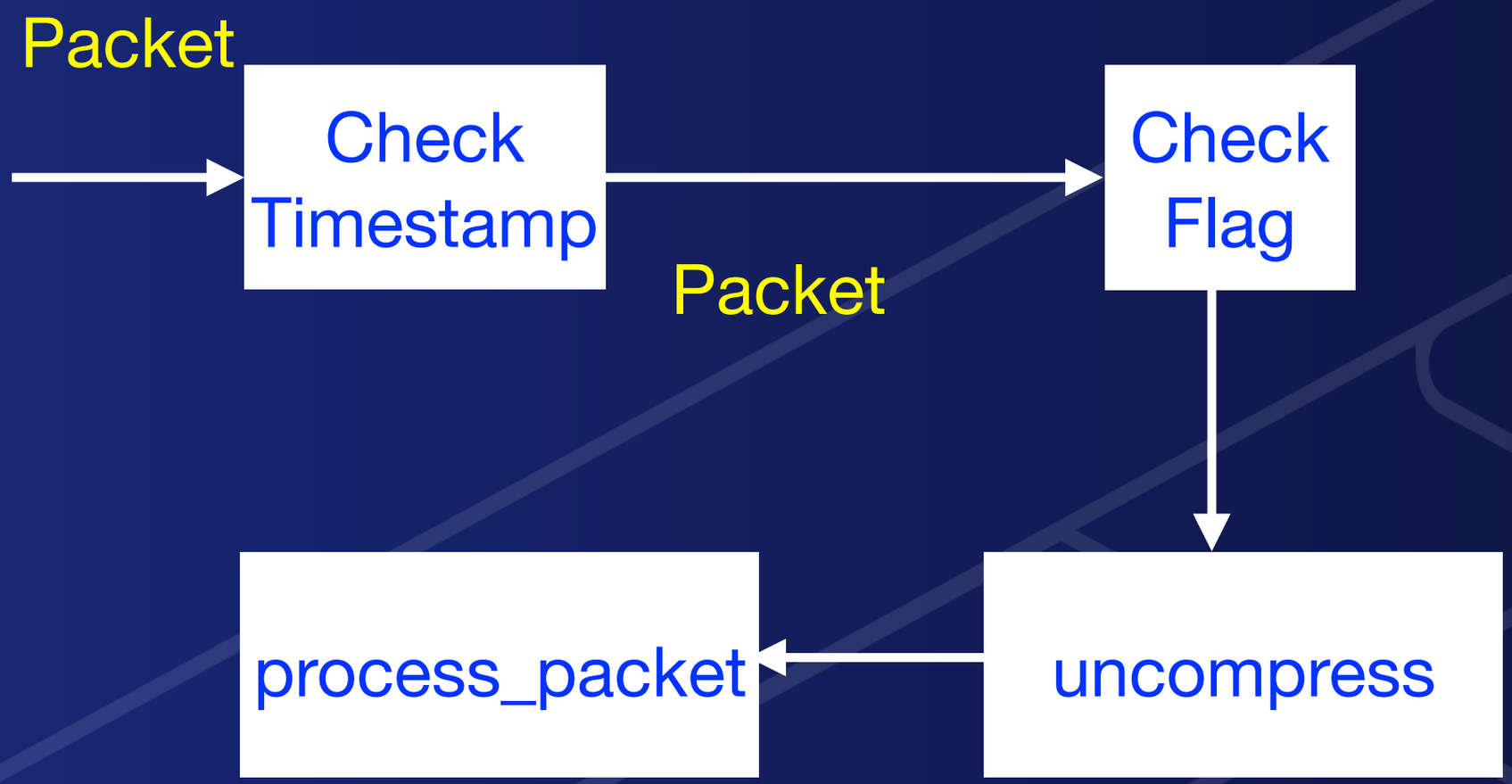

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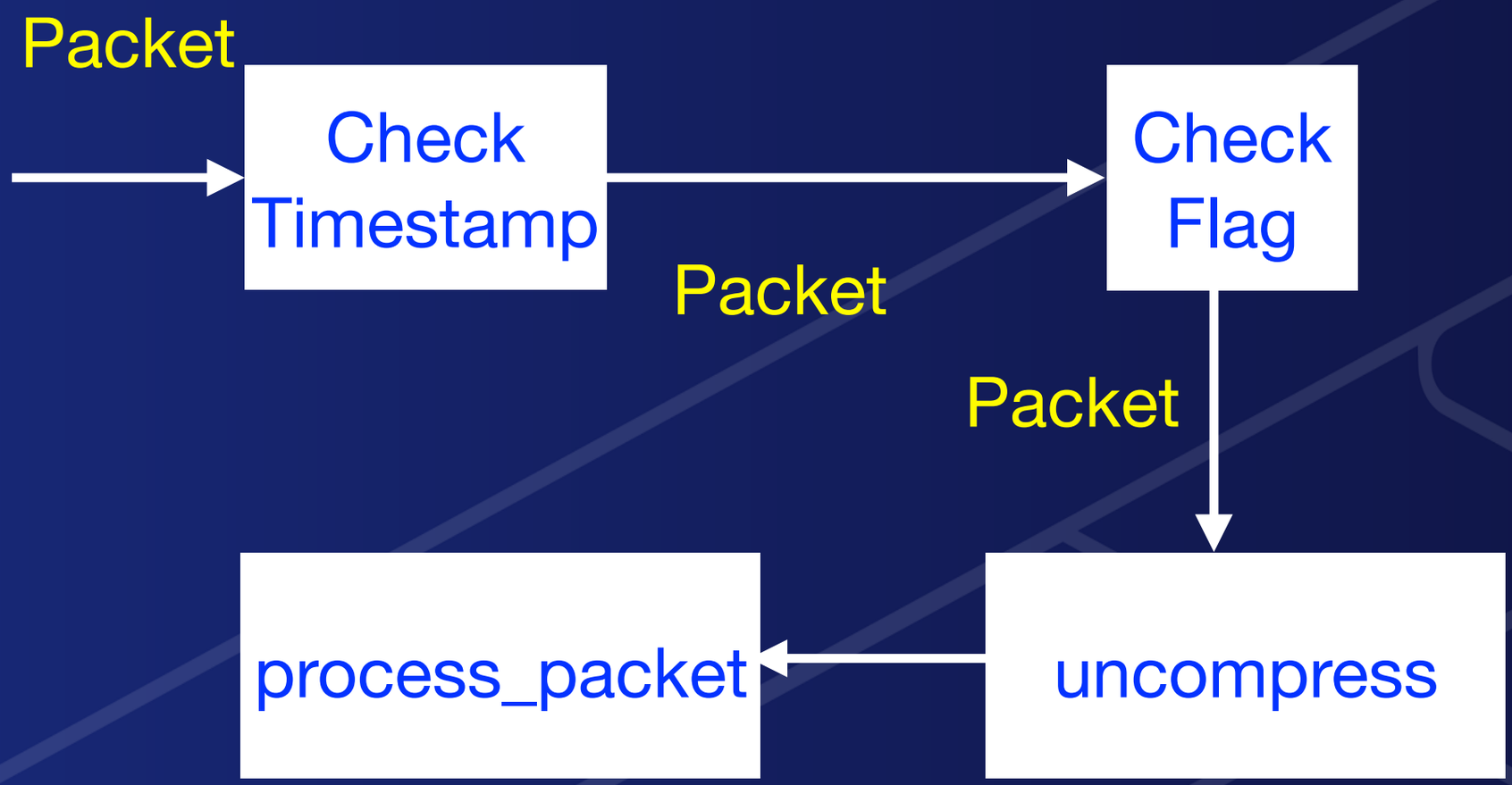

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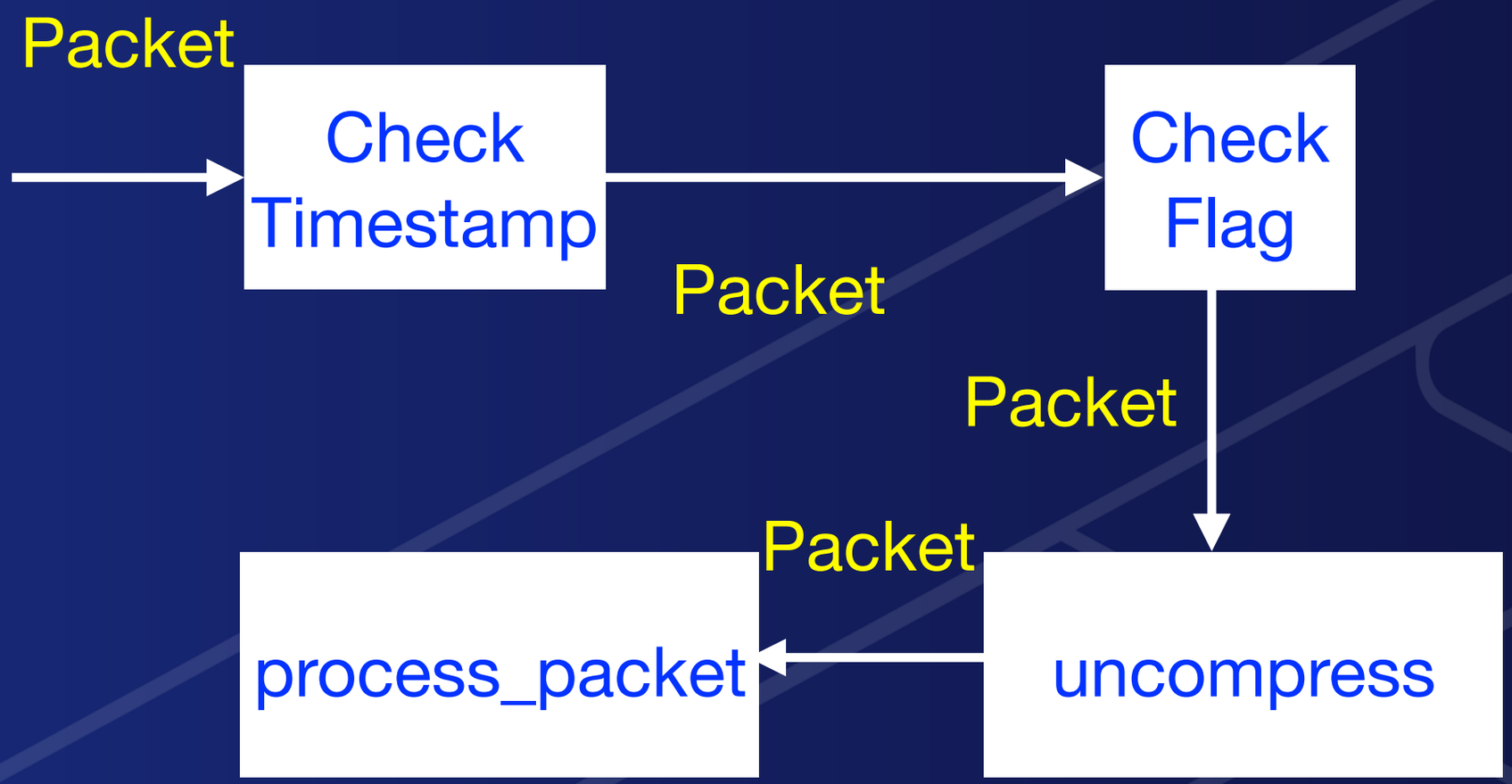

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- Less than I want on the latter
- Key concept - adding a feature should require zero/little change to the existing implementation
- Very low coupling, very high cohesion
- Recount parts of a 32 year quest

Journey Before Destination

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The most important words a man can say are, “I will do better.” These are not the most important words any man can say. I am a man, and they are what I needed to say. The ancient code of the Knights Radiant says “journey before destination.” Some may call it a simple platitude, but it is far more. A journey will have pain and failure. It is not only the steps forward that we must accept. It is the stumbles. The trials. The knowledge that we will fail. That we will hurt those around us. But if we stop, if we accept the person we are when we fall, the journey ends. That failure becomes our destination. To love the journey is to accept no such end. I have found, through painful experience, that the most important step a person can take is always the next one.

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A Three-Way Love Affair

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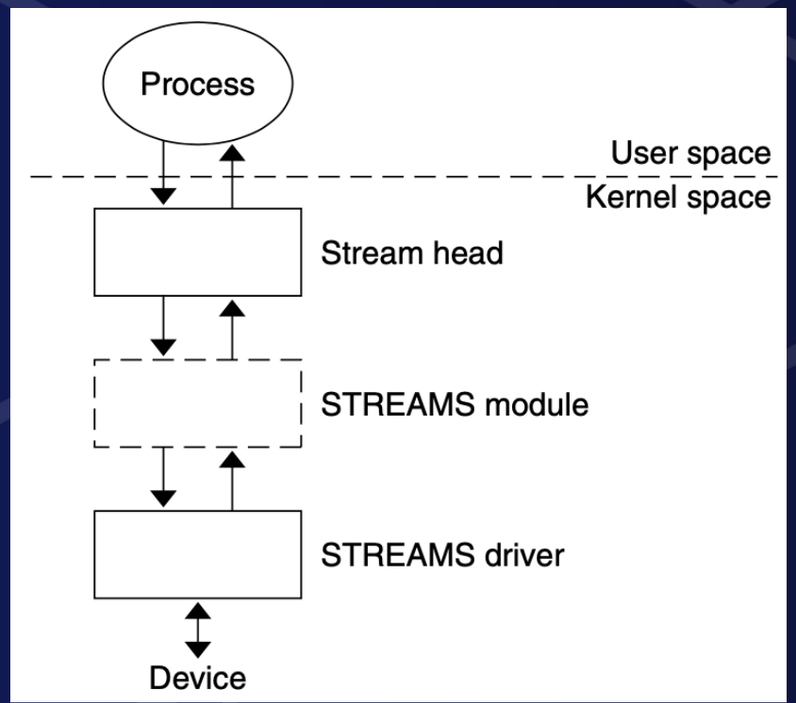

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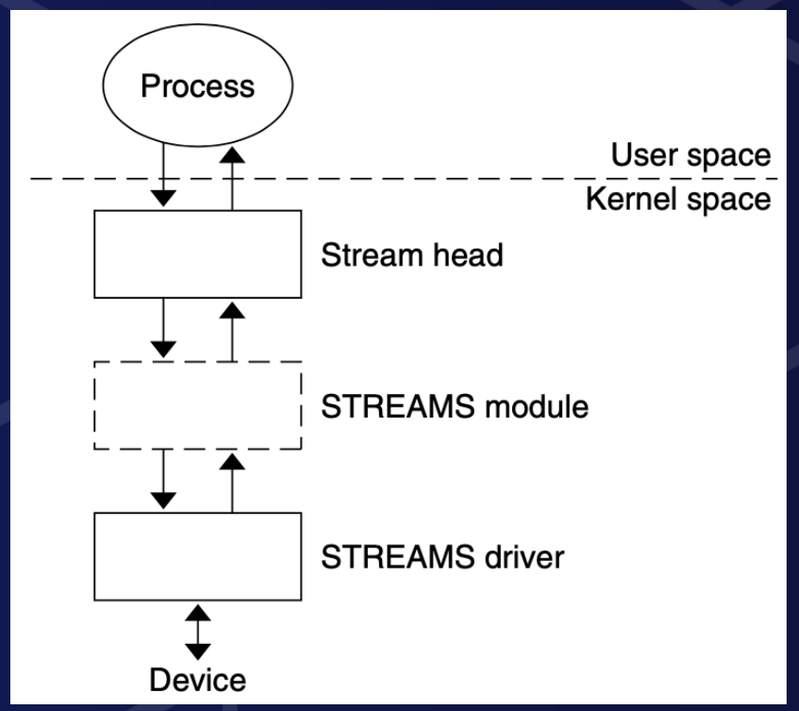

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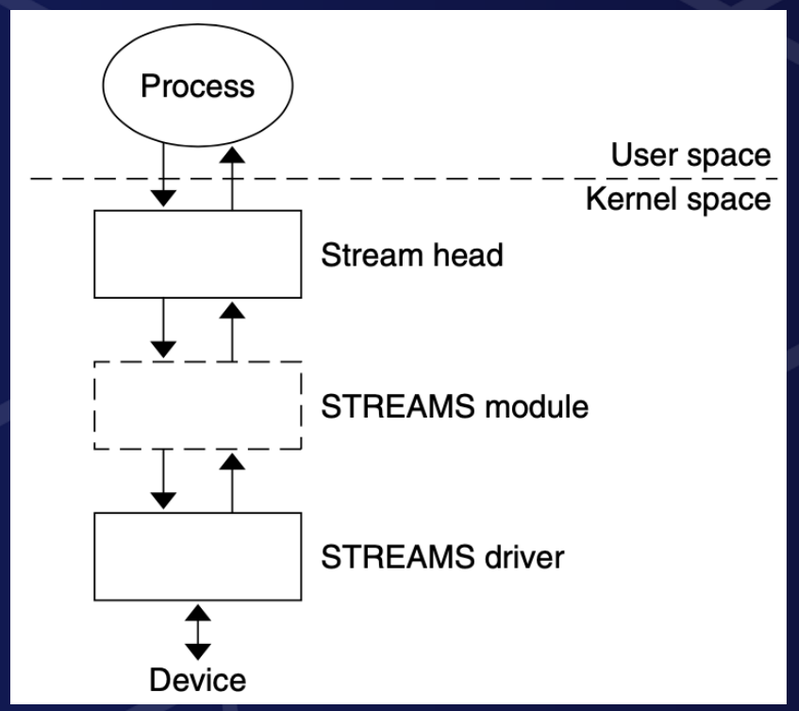

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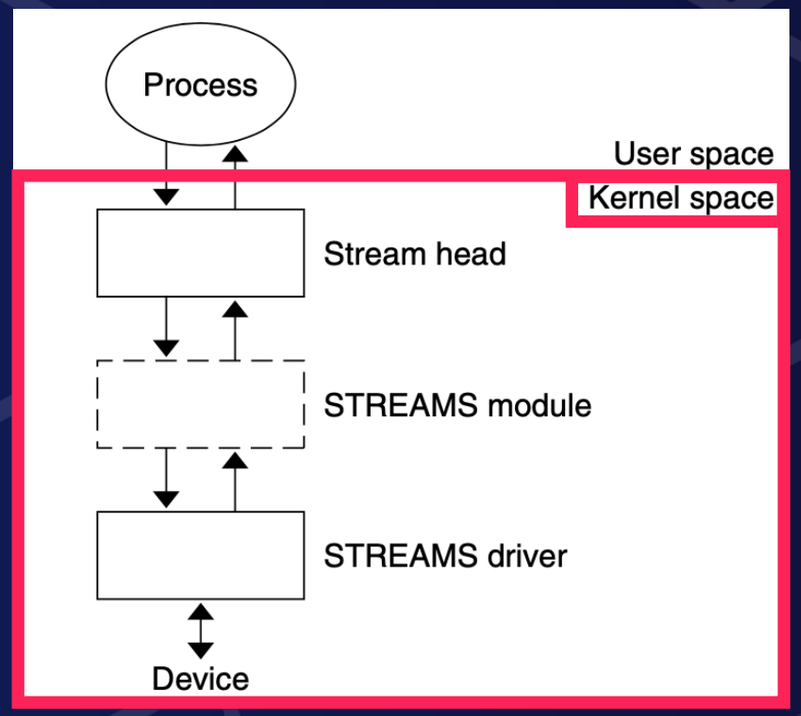

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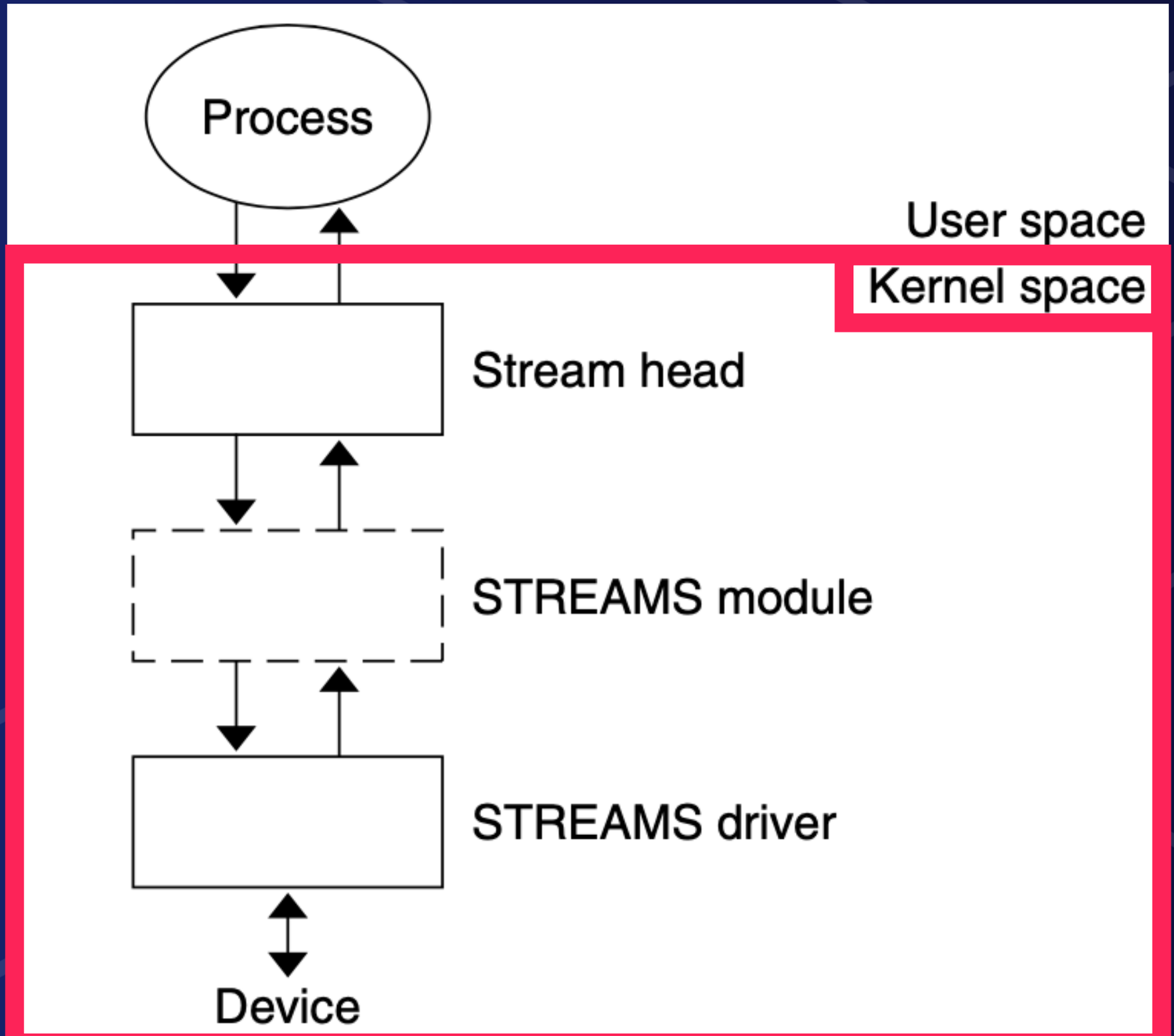

A Beginning...

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tmp = a
a = b
b = tmp

A Beginning...

```
tmp := a;
a := b;
b := tmp;
```

My Early Use of C++

- c / cfront
- get off punch cards

Grad School and the AI Winter

Grad School and Publications

Hagins, Biswas, Yu, Model-Based Diagnosis in the Process-Ontology Framework,
The Second AAAI Workshop on Model Based Reasoning, Boston, MA, July 1990

Biswas, Yu, Hagins, Strobel, Kendall, Cannon, Bezdek, An Efficient Scheme for Characterizing Hydrocarbon Plays for Analogical Analysis
AAPG Annual Convention, San Francisco, CA, June 1990

Biswas, Yu, Hagins, Strobel, Kendall, Cannon, Bezdek, PLAYMAKER: A Knowledge-Based Approach to Characterizing Hydrocarbon Plays
Applications of AI VIII (SPIE), Orlando, FL, April 1990

Biswas, Strobel, Hagins, Kendall, Cannon, Bezdek, An Associational Scheme for Characterizing Hydrocarbon Plays for Analogical Reasoning
IEEE Expert, March 1990

Biswas, Hagins, Debelak, Qualitative Modeling in Engineering Applications
1989 IEEE Conference on Systems, Man, and Cybernetics, Cambridge, MA, November 1989

Weinberg, Hagins, Biswas, Extending Temporal Reasoning in Process-Oriented Qualitative Reasoning
Proceedings of IJCAI-89 Workshop on Model Based Reasoning, Detroit, MI, August 1989

Debelak, Biswas, Hagins, Qualitative Modeling in Chemical Engineering Applications
American Institute of Chemical Engineers: 1989 Summer National Meeting, August 20, 1989

Grad School and Winning the Lottery

SVR4 SMP Unix Kernel

Cool Stuff!!!

Siemens Stromberg-Carlson

Goal

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- My goal - add feature with little or no change to existing design and/or implementation
- Fortunately, they had used System V IPC

System V IPC

Message queues

System V message queues allow data to be exchanged in units called messages. Each messages can have an associated priority, POSIX message queues provide an alternative API for achieving the same result; see mq_overview(7).

The System V message queue API consists of the following system calls:

msgget(2)
: Create a new message queue or obtain the ID of an existing message queue. This call returns an identifier that is used in the remaining APIs.

msgsnd(2)
: Add a message to a queue.

msgrcv(2)
: Remove a message from a queue.

msgctl(2)
: Perform various control operations on a queue, including deletion.

https://man7.org/linux/man-pages/man7/sysvipc.7.html

System V IPC

Semaphore sets

System V semaphores allow processes to synchronize their actions. System V semaphores are allocated in groups called sets; each semaphore in a set is a counting semaphore. POSIX semaphores provide an alternative API for achieving the same result; see sem_overview(7).

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semop(2)
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System V IPC

Shared memory segments

System V shared memory allows processes to share a region a memory (a "segment"). POSIX shared memory is an alternative API for achieving the same result; see shm_overview(7).

The System V shared memory API consists of the following system calls:

shmget(2)
: Create a new segment or obtain the ID of an existing segment. This call returns an identifier that is used in the remaining APIs.

shmat(2)
: Attach an existing shared memory object into the calling process's address space.

shmdt(2)
: Detach a segment from the calling process's address space.

shmctl(2)
: Perform various control operations on a segment, including deletion.

https://man7.org/linux/man-pages/man7/sysvipc.7.html

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System V IPC

Shared memory segments

System V shared memory allows processes to share a region a memory (a "segment"). POSIX shared memory is an alternative API for achieving the same result; see shm_overview(7).

The System V shared memory API consists of the following system calls:

shmget(2)
: Create a new segment or obtain the ID of an existing segment. This call returns an identifier that is used in the remaining APIs.

shmat(2)
: Attach an existing shared memory object into the calling process's address space.

shmdt(2)
: Detach a segment from the calling process's address space.

shmctl(2)
: Perform various control operations on a segment, including deletion.

https://man7.org/linux/man-pages/man7/sysvipc.7.html

Message Queue

```c
int msgget(key_t key, int msgflg)
{ /* implementation */ }

int msgsnd(int msqid, const void *msgp, size_t msgsz,
    int msgflg)
{ /* implementation */ }

ssize_t msgrcv(int msqid, void *msgp, size_t msgsz, long
msgtyp, int msgflg)
{ /* implementation */ }

int msgctl(int msqid, int cmd, struct msqid_ds *buf)
{ /* implementation */ }
```

Semaphore

```c
int semget(key_t key, int nsems, int semflg)
{ /* implementation */ }

int semop(int semid, struct sembuf *sops, size_t nsops)
{ /* implementation */ }

int semctl(int semid, int semnum, int cmd, ...)
{ /* implementation */ }
```

Relink

```
g++ blah blah blah -ldcom.a
```

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Kernel STREAMS module: DCOM

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Kernel STREAMS module: DCOM

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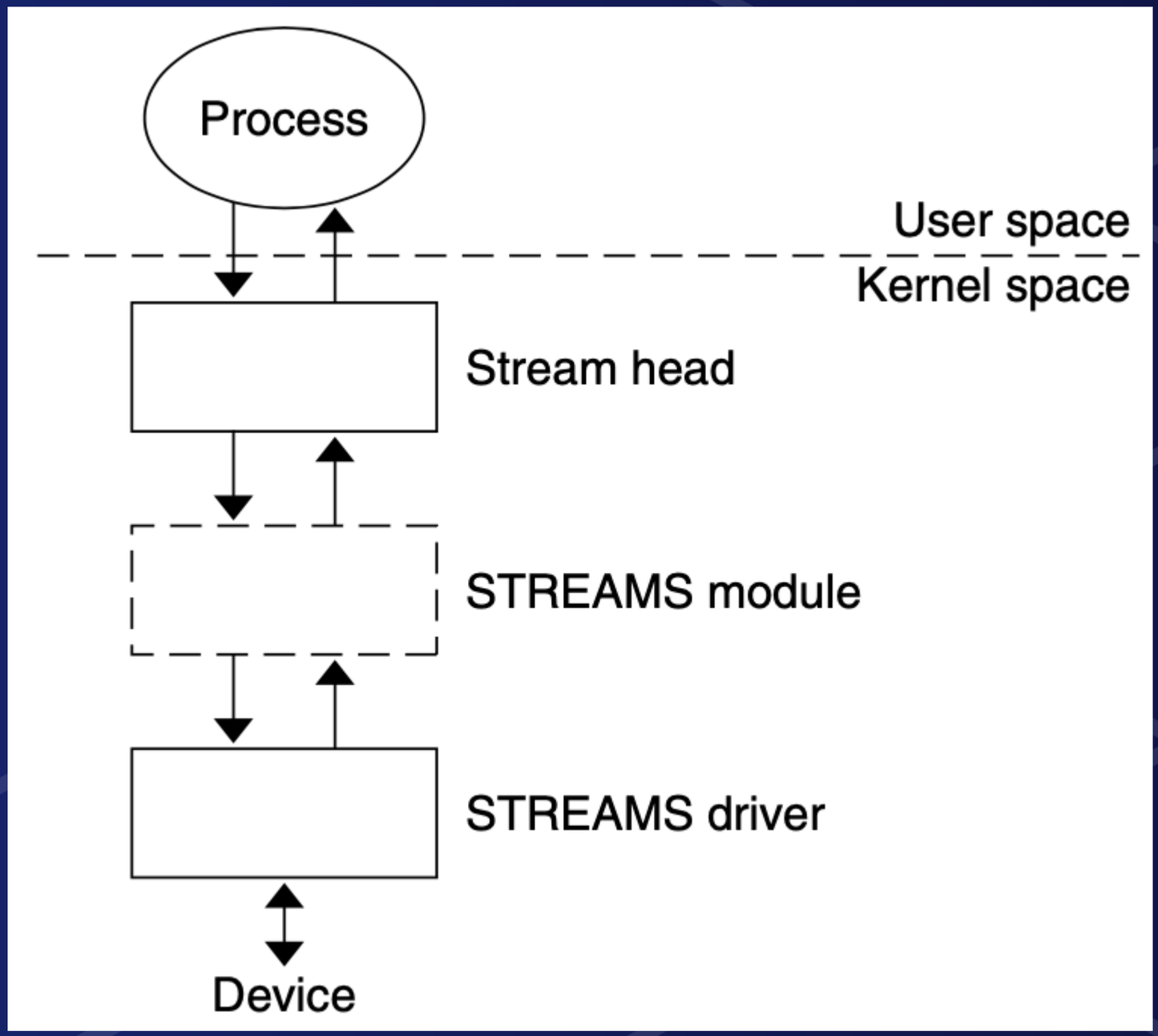
Coupling vs. Cohesion

"One goal of design is to minimize coupling between parts and to maximize cohesion within them."

Multi-Paradigm Design for C++ *James Coplien*

Love at First Sight



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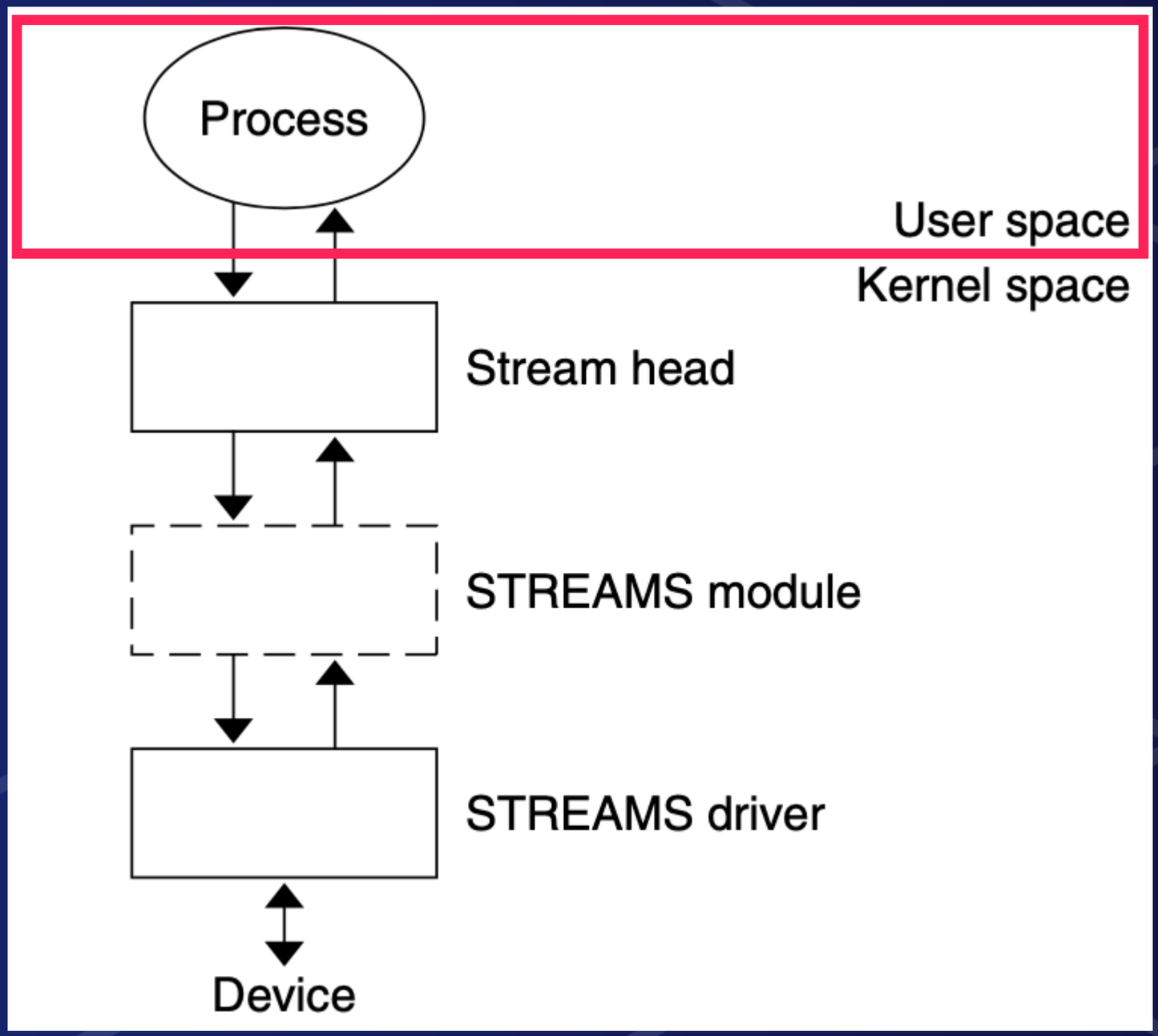

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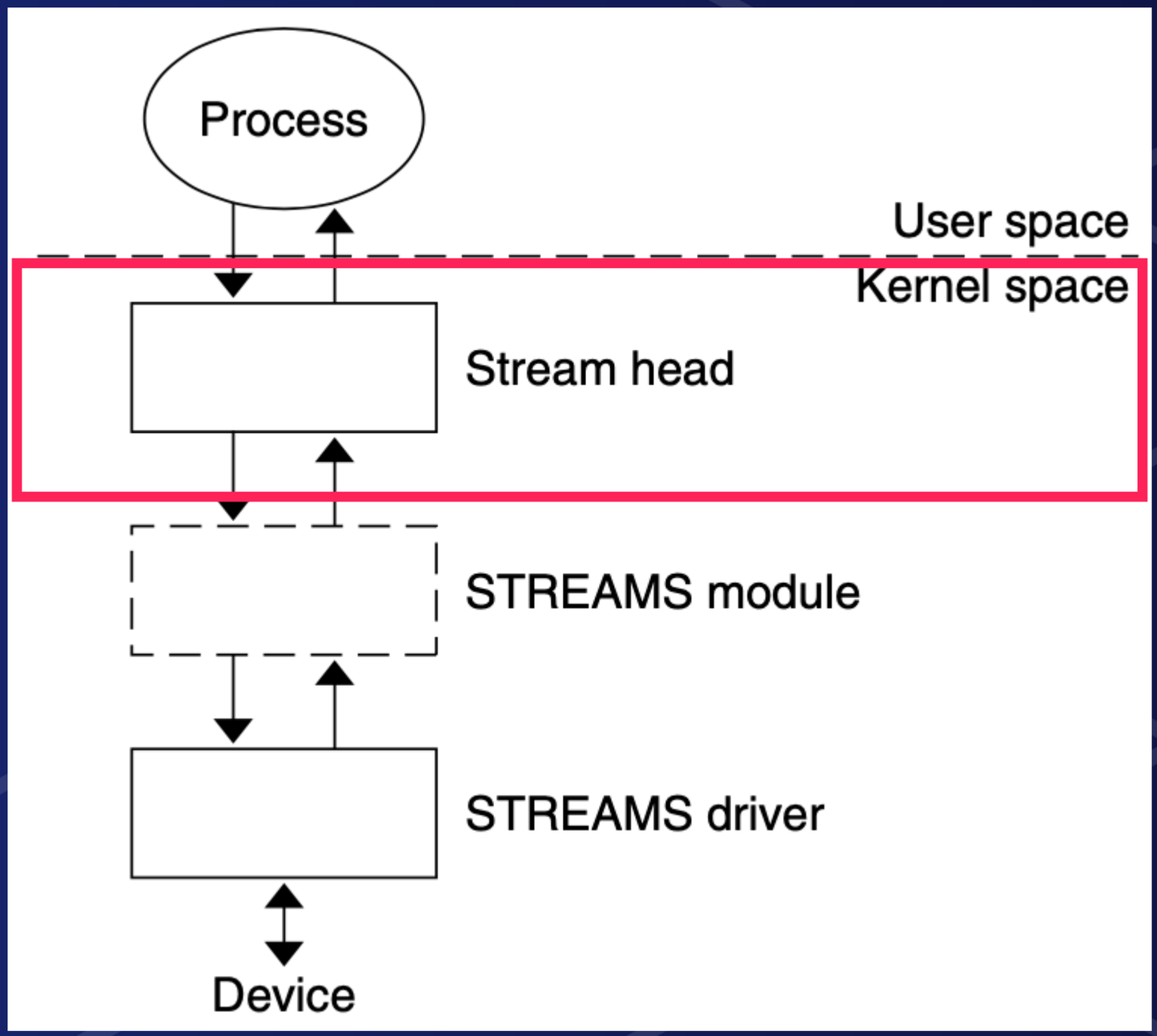

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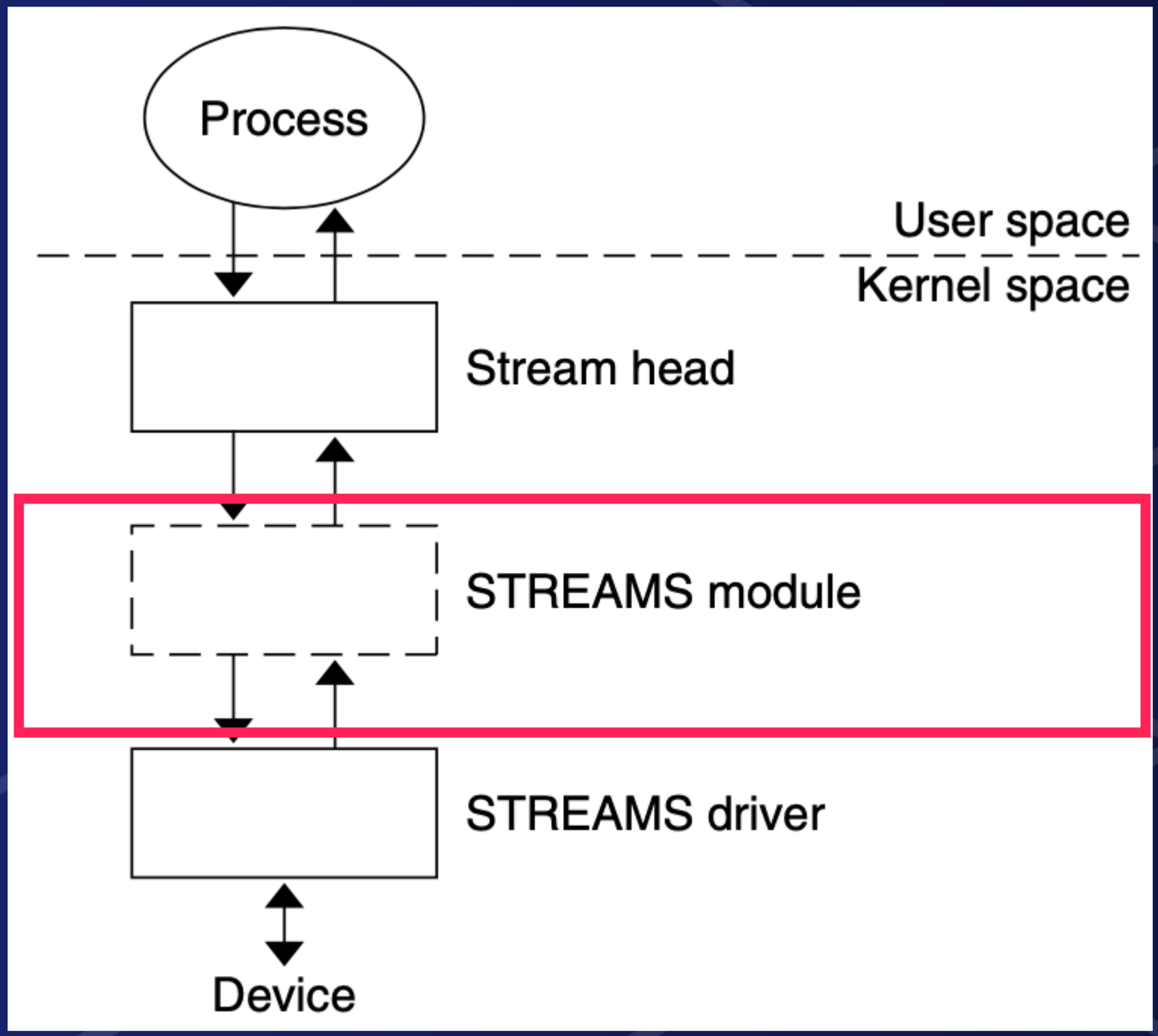

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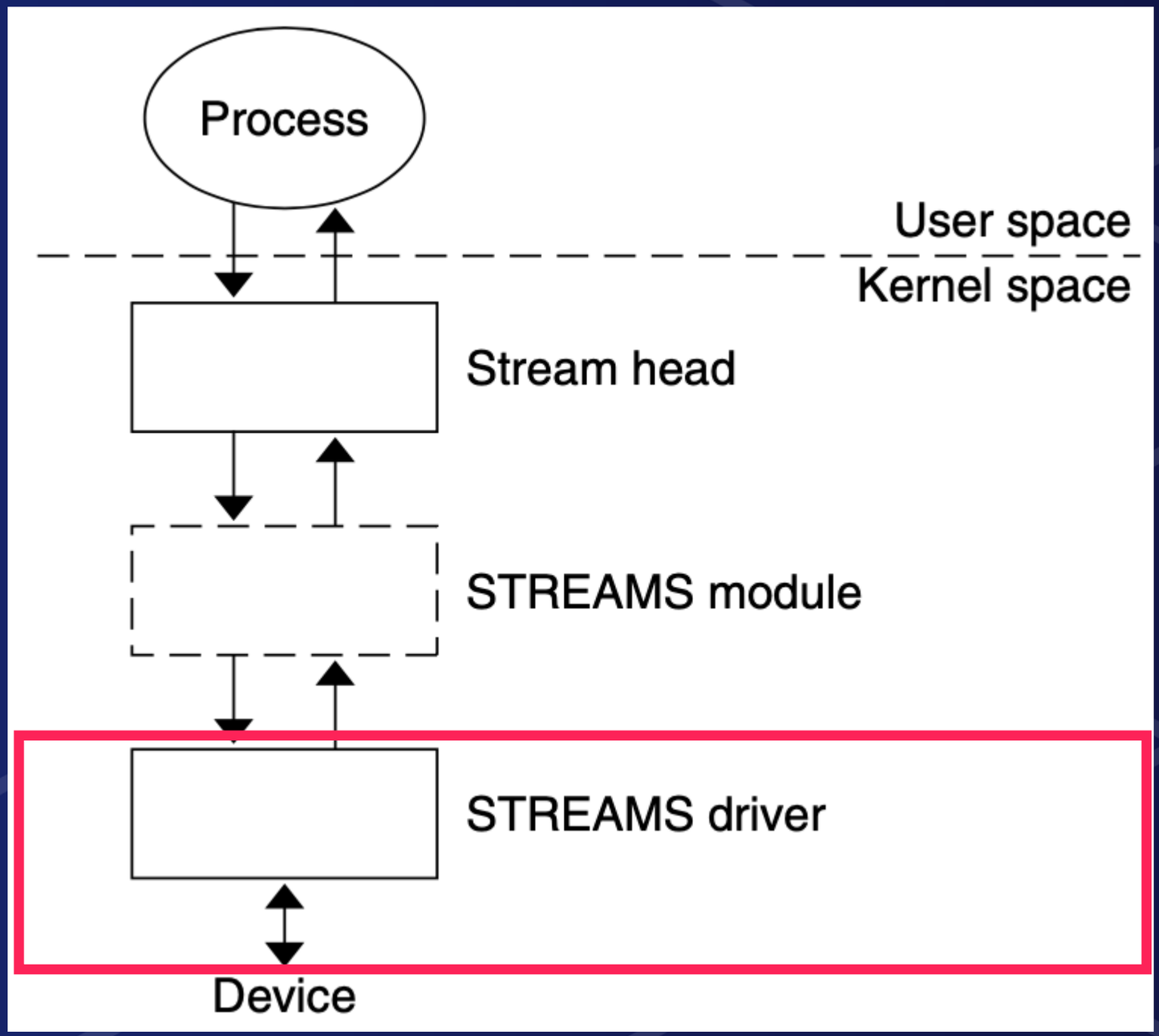

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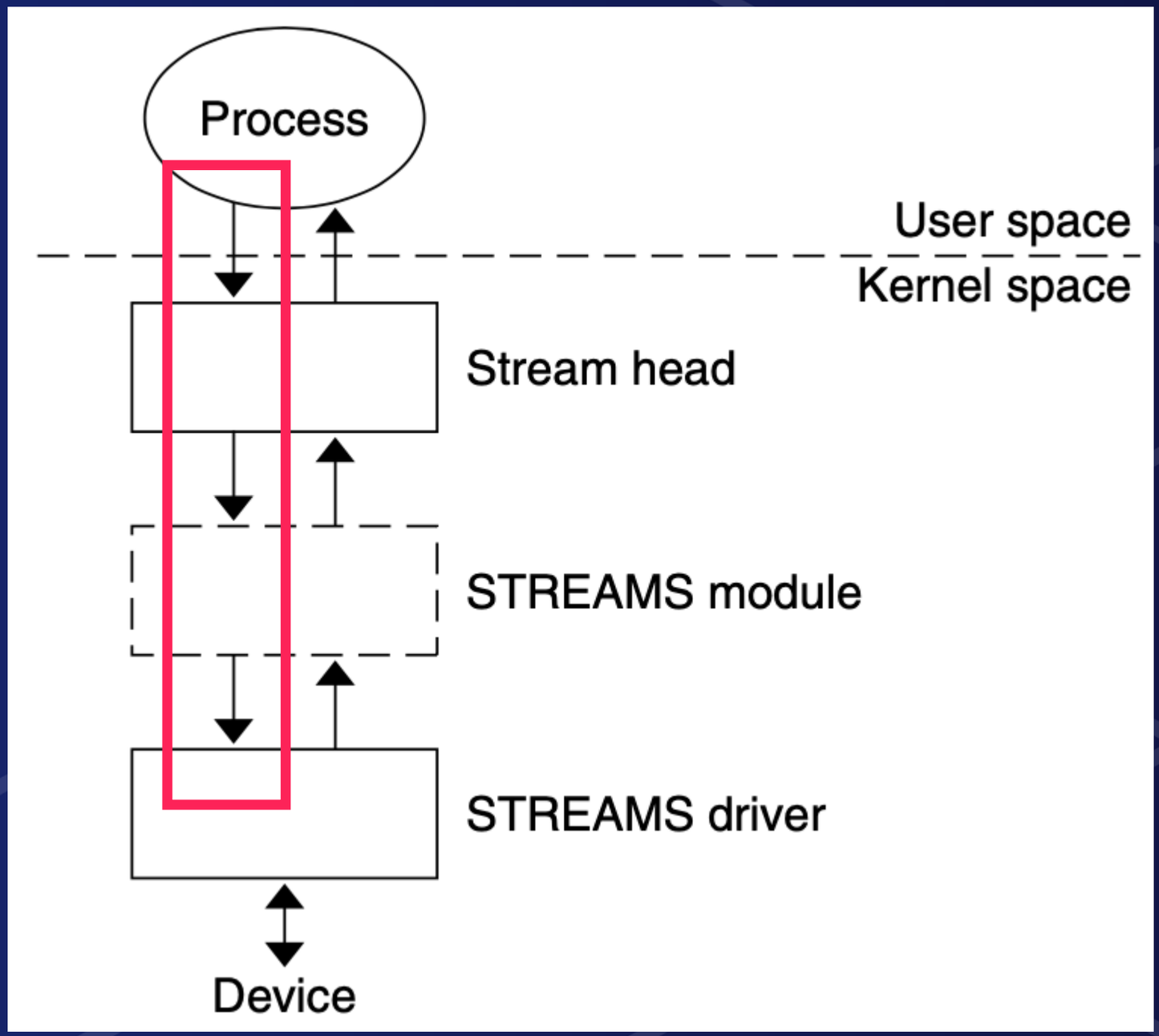

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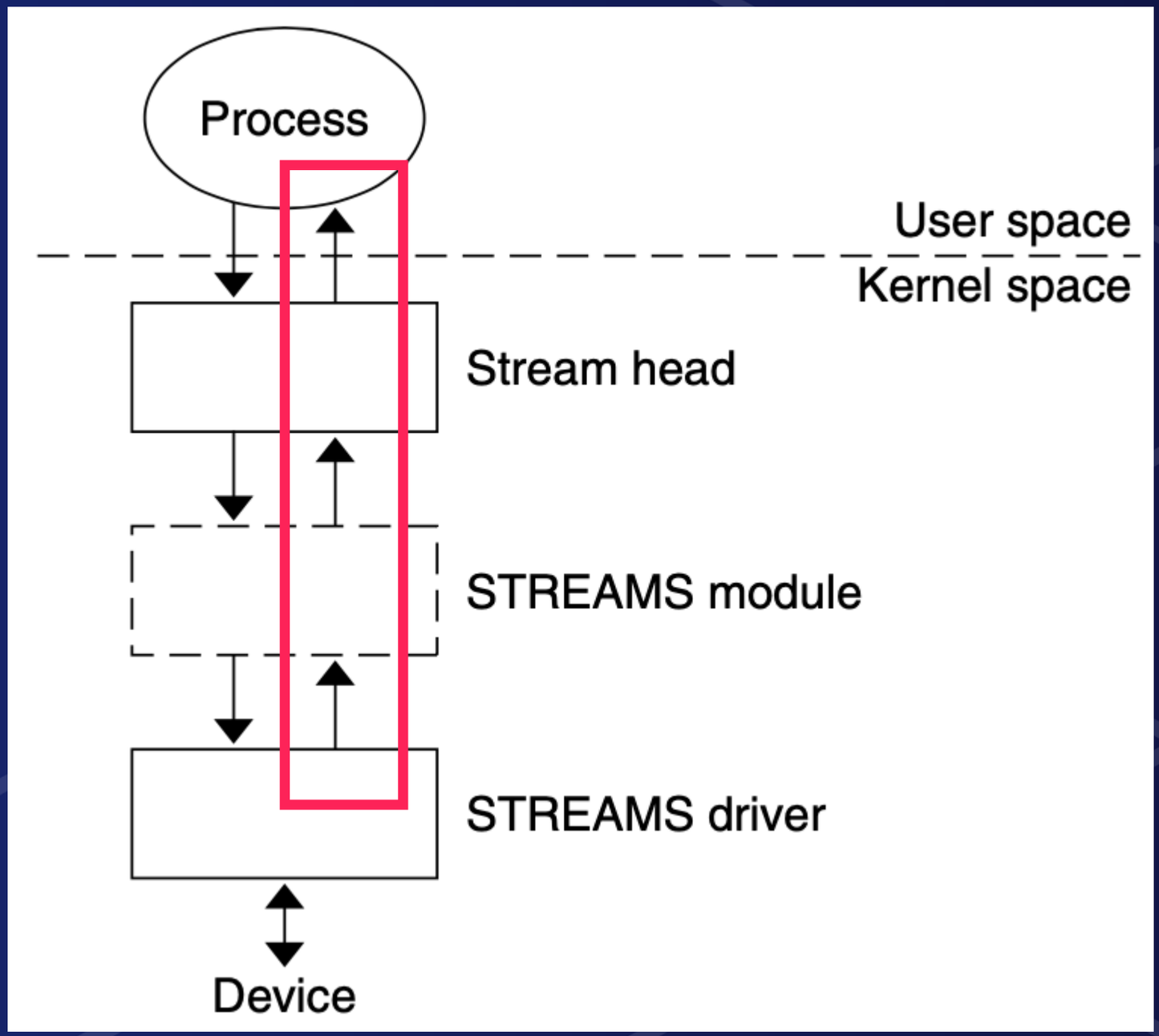

STREAMS Resources

STREAMS Resources

STREAMS Programming Guide - Oracle
https://docs.oracle.com/cd/E26502_01/html/E35856/index.html

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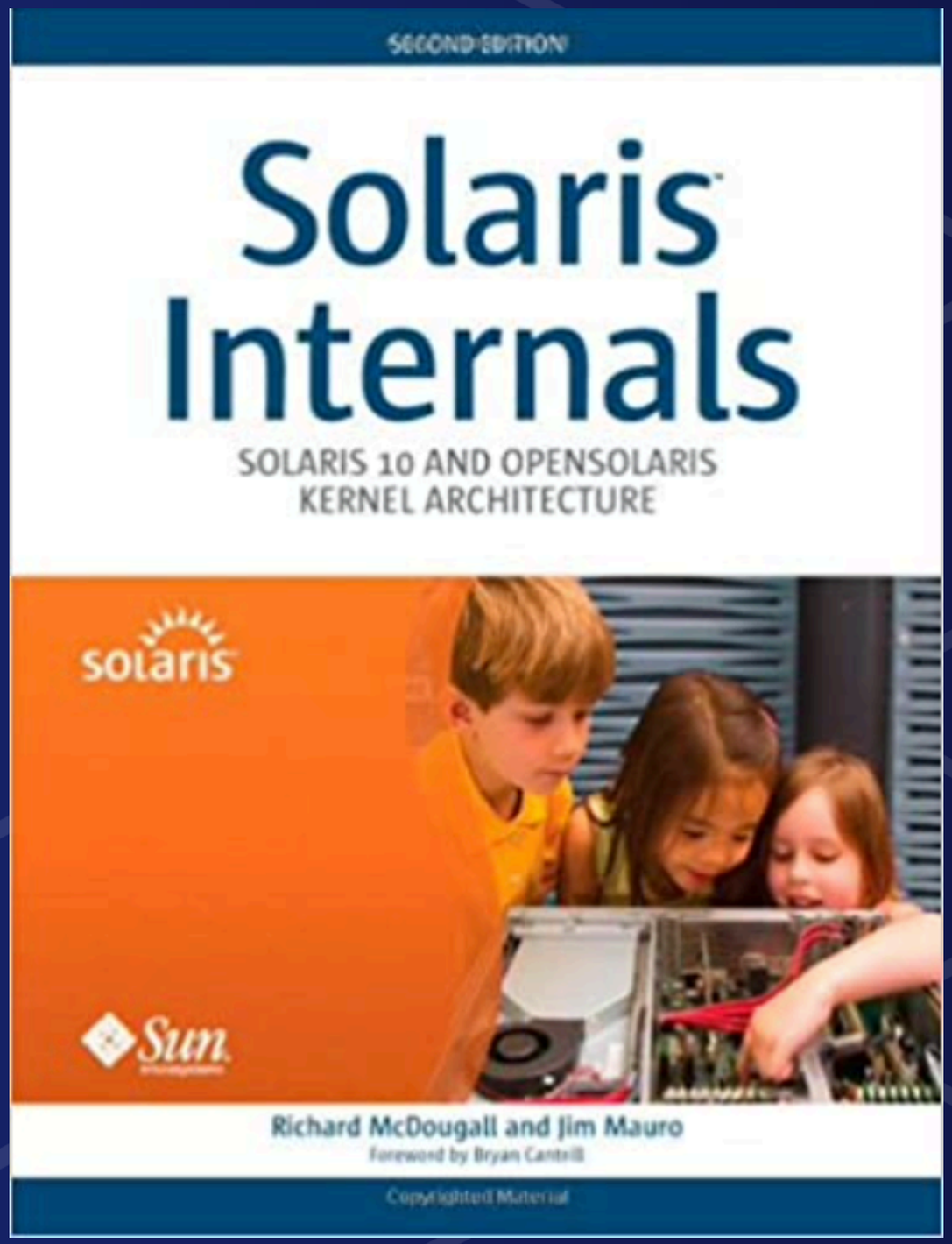
Lots of other PDF resources available online
google is your friend

STREAMS Resources



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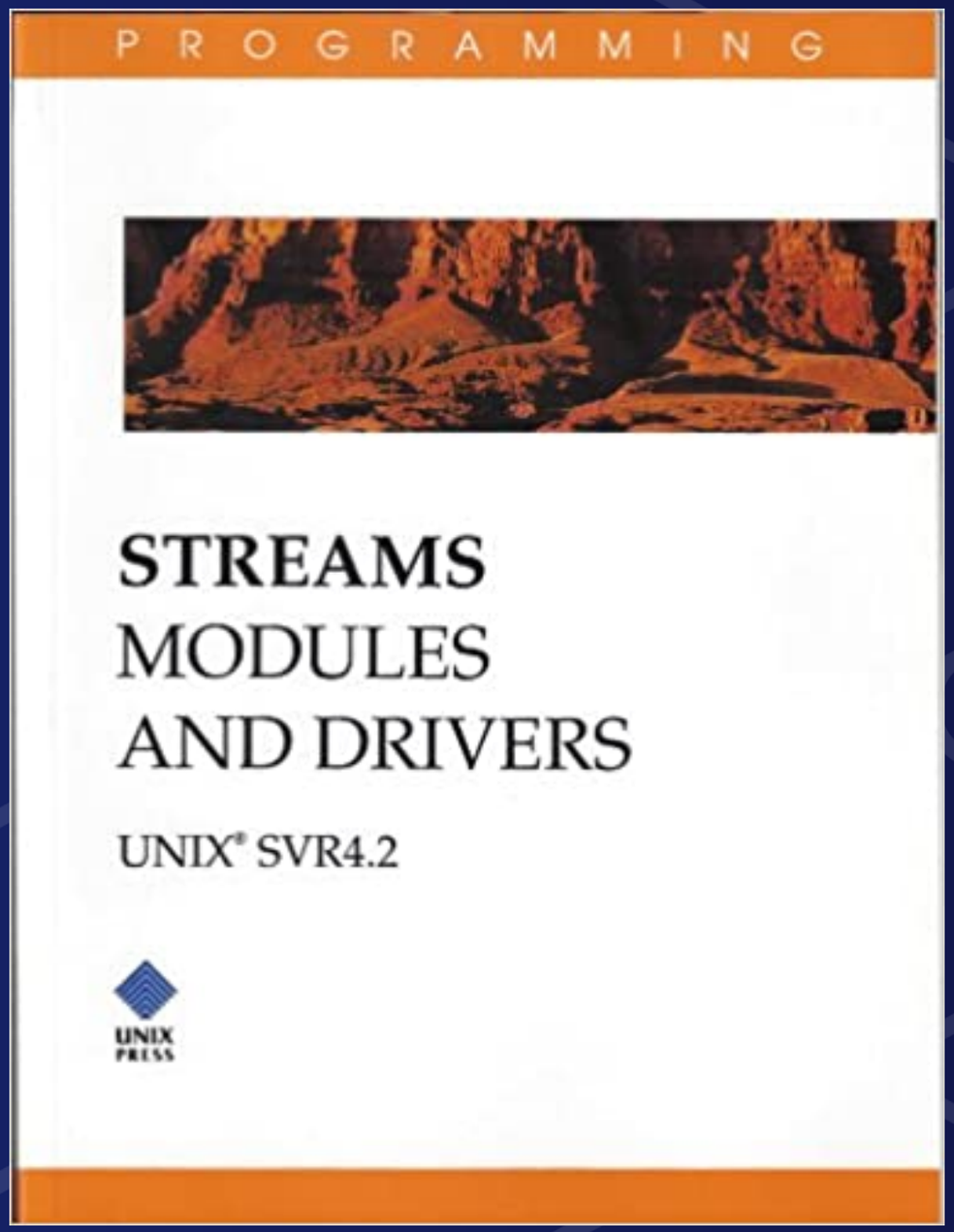

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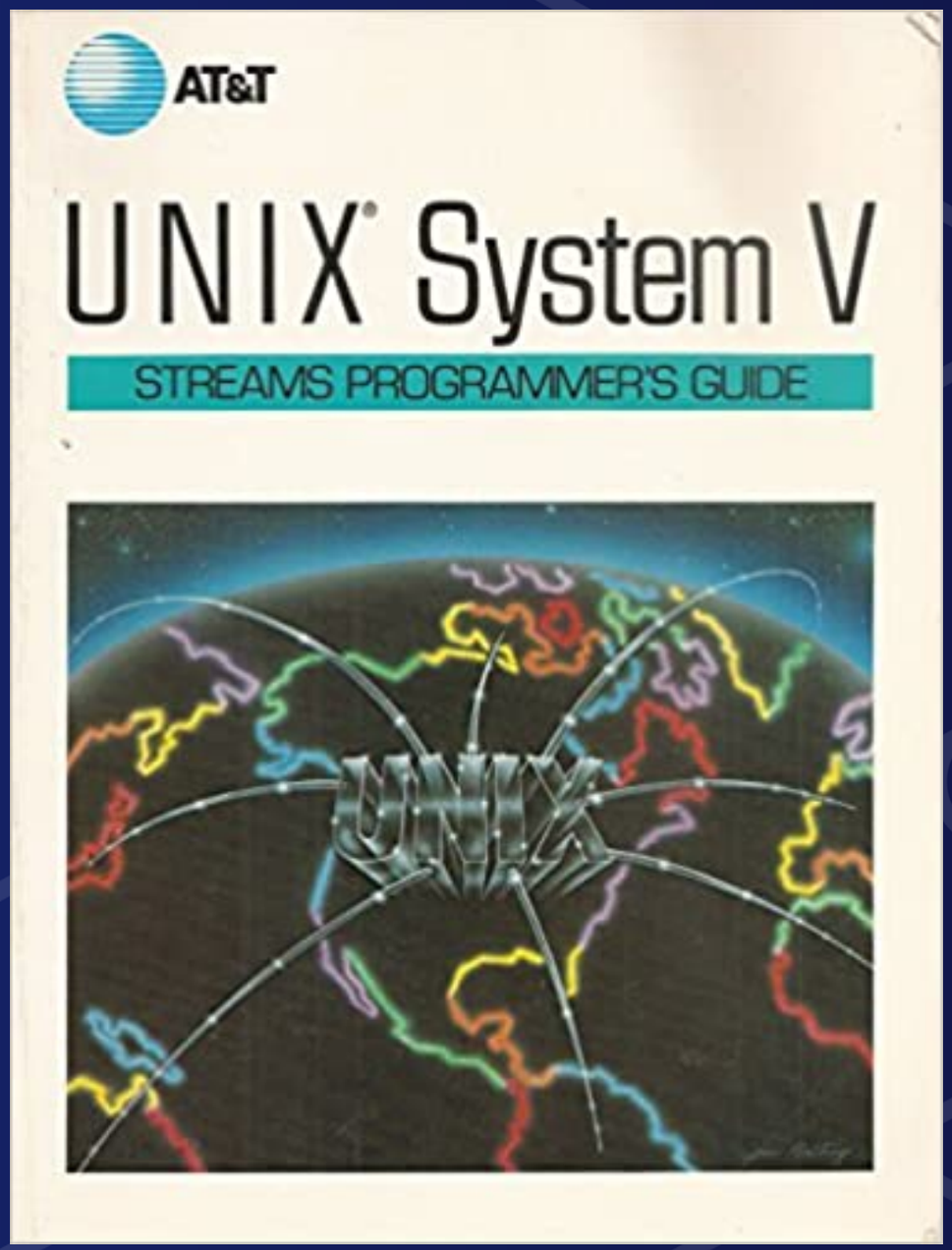

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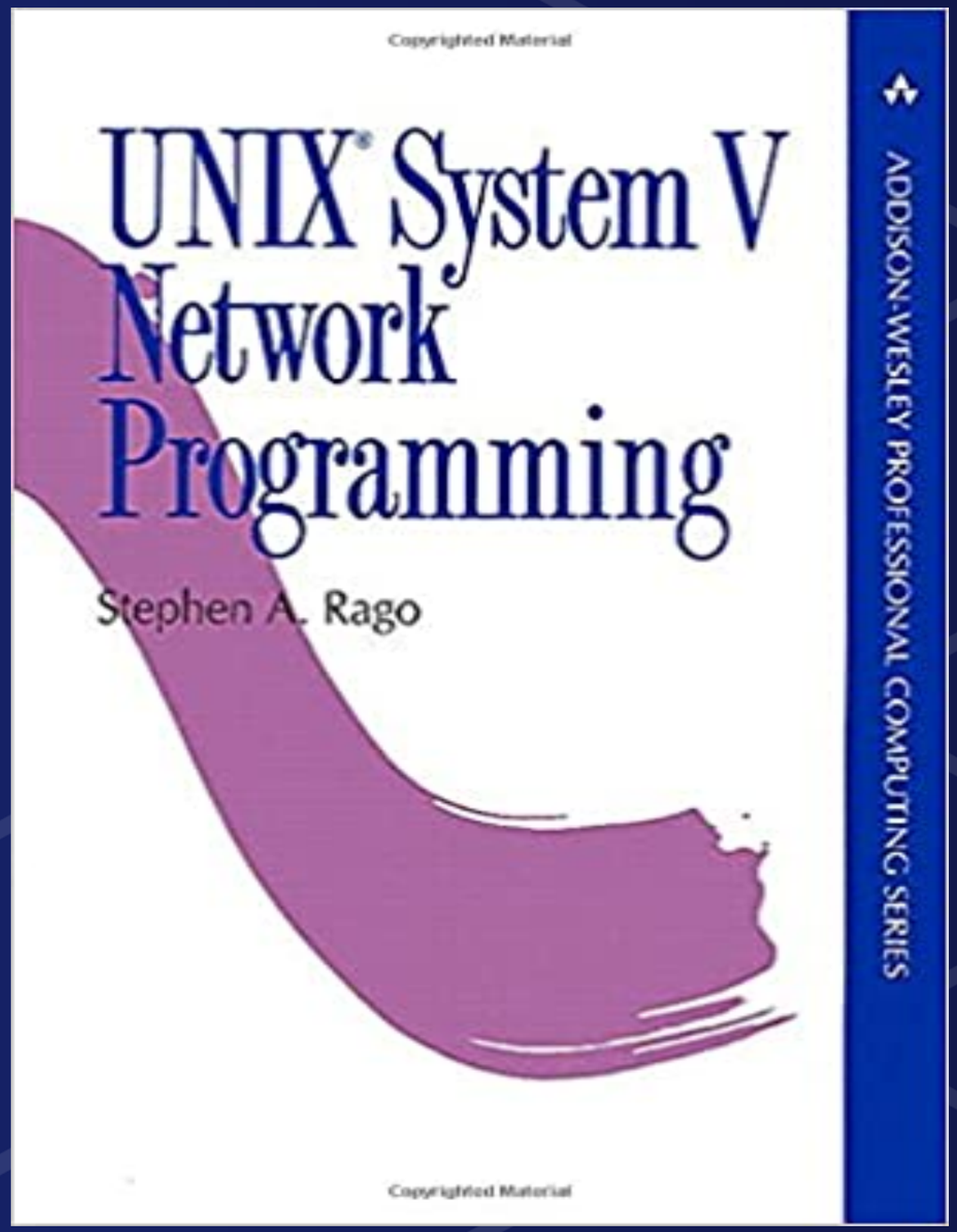

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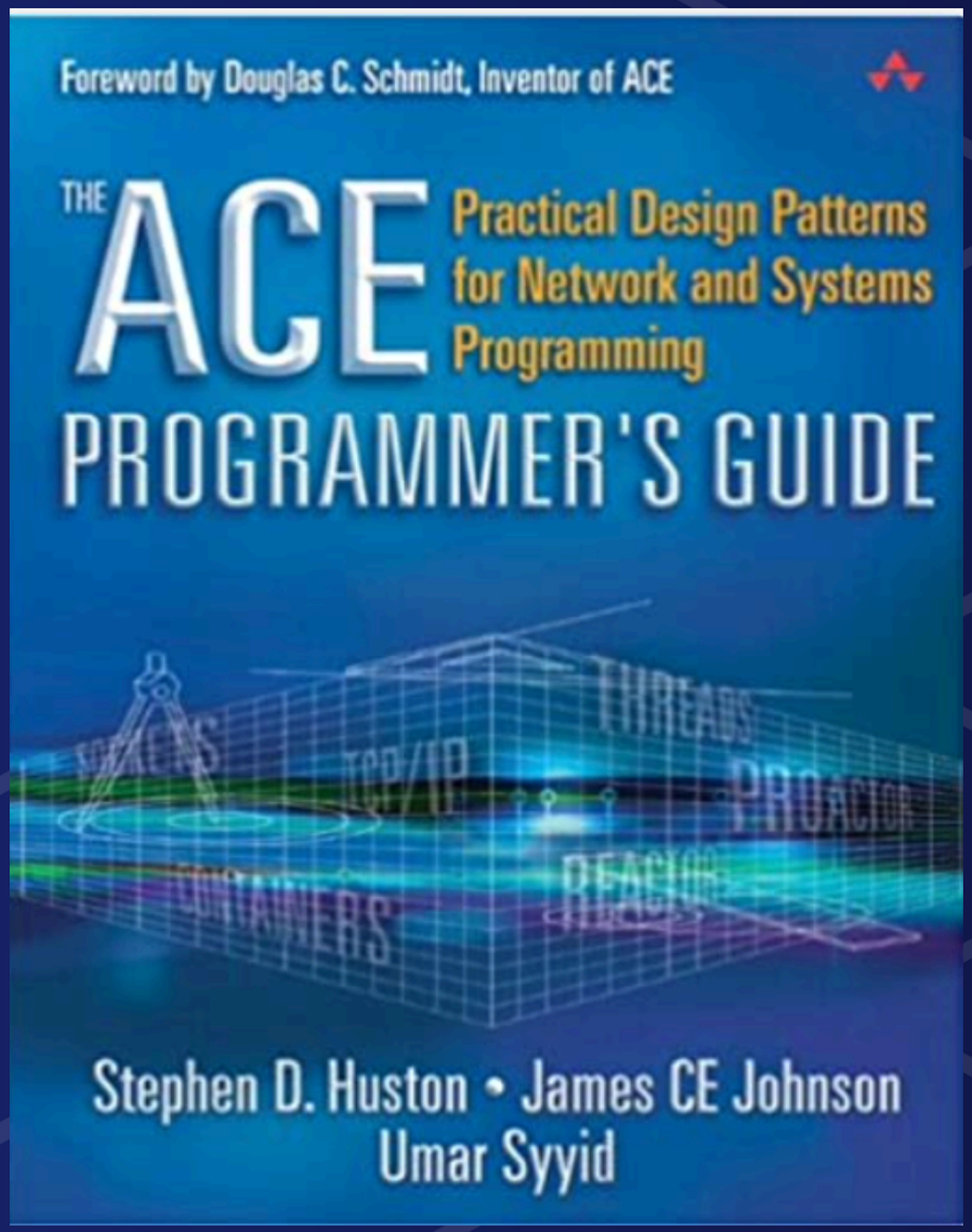

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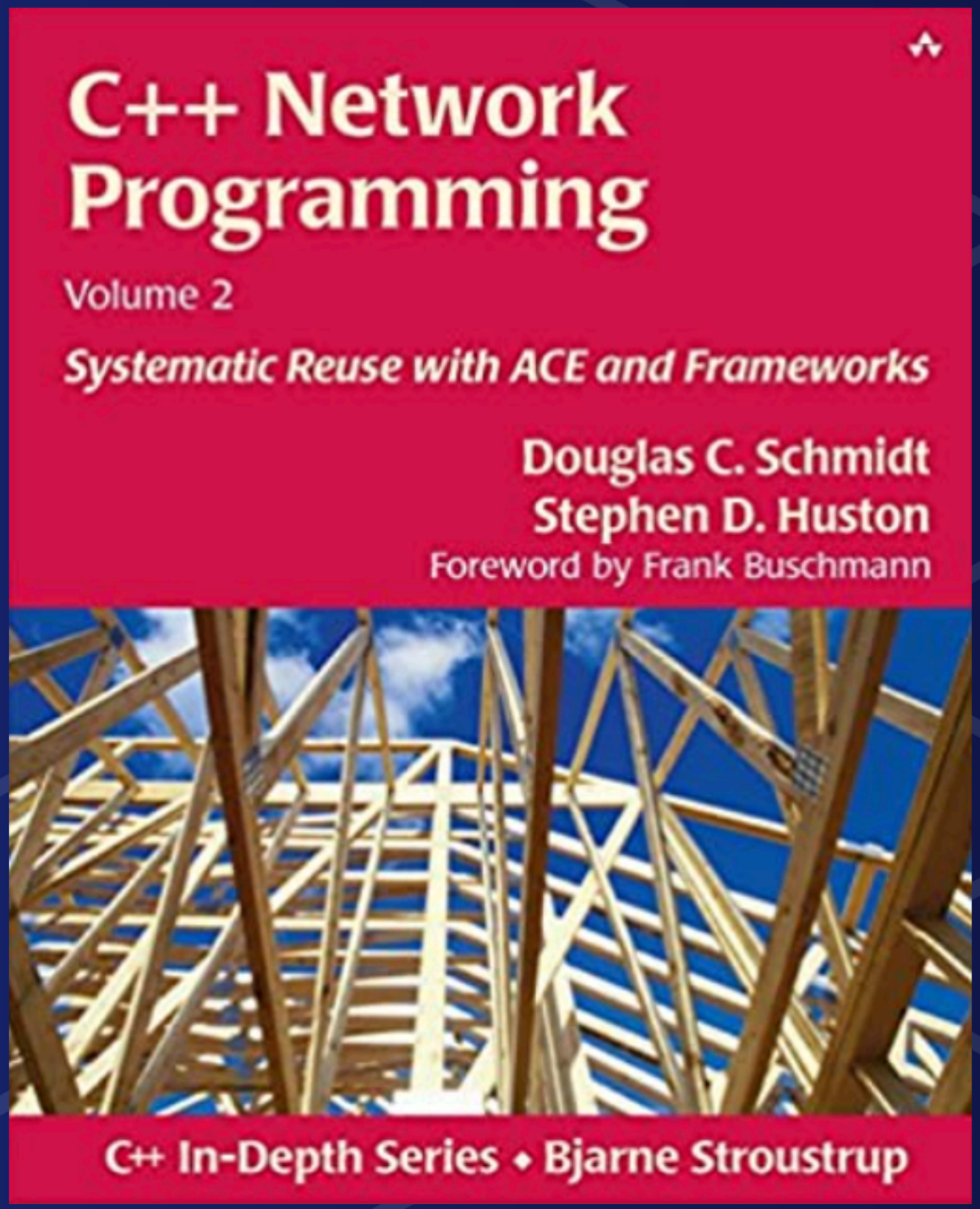

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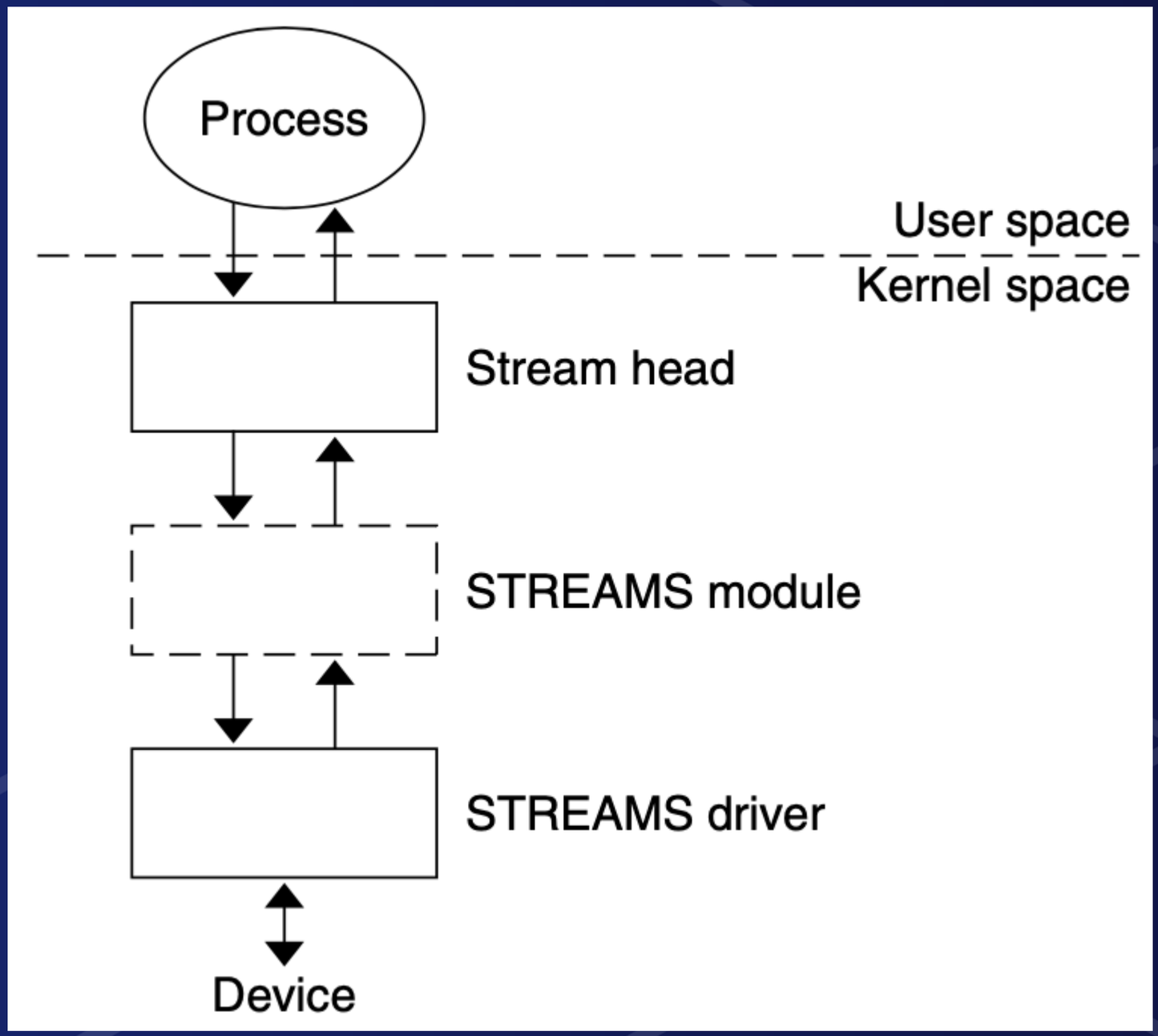

Love at Second Sight?

```
#include <sys/fcntl.h>
#include <stdio.h>

main()
{
        char buf[1024];
        int fd, count;

        if ((fd = open("/dev/ttya", O_RDWR)) < 0) {
            perror("open failed");
            exit(1);
        }
        while ((count = read(fd, buf, sizeof(buf))) > 0) {
            if (write(fd, buf, count) != count) {
                perror("write failed");
                break;
            }
        }
        exit(0);
}
```

Love at Second Sight?

https://www.youtube.com/watch?v=89eEa3RvCF4

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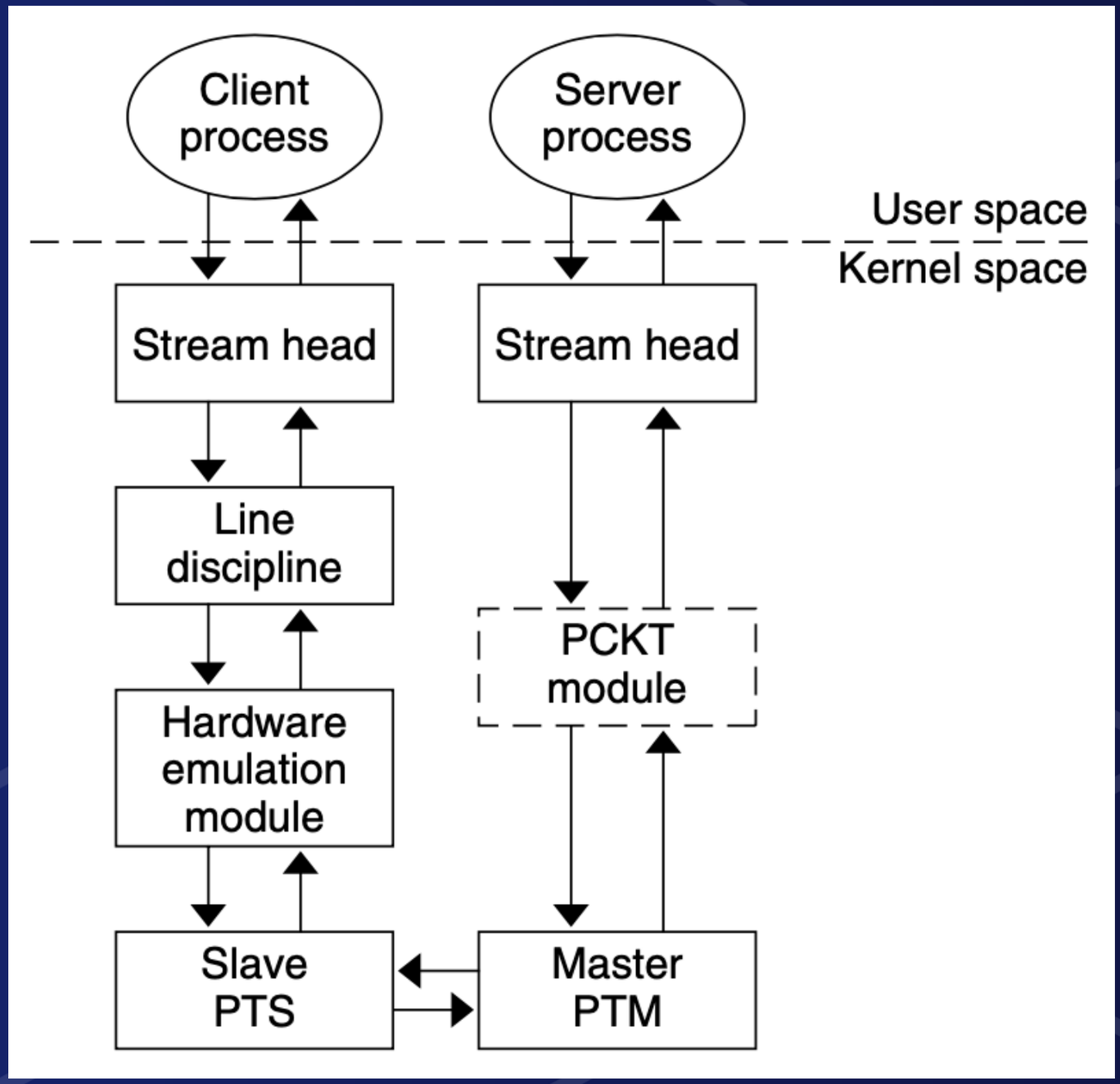
Pseudo-TTY in STREAMS



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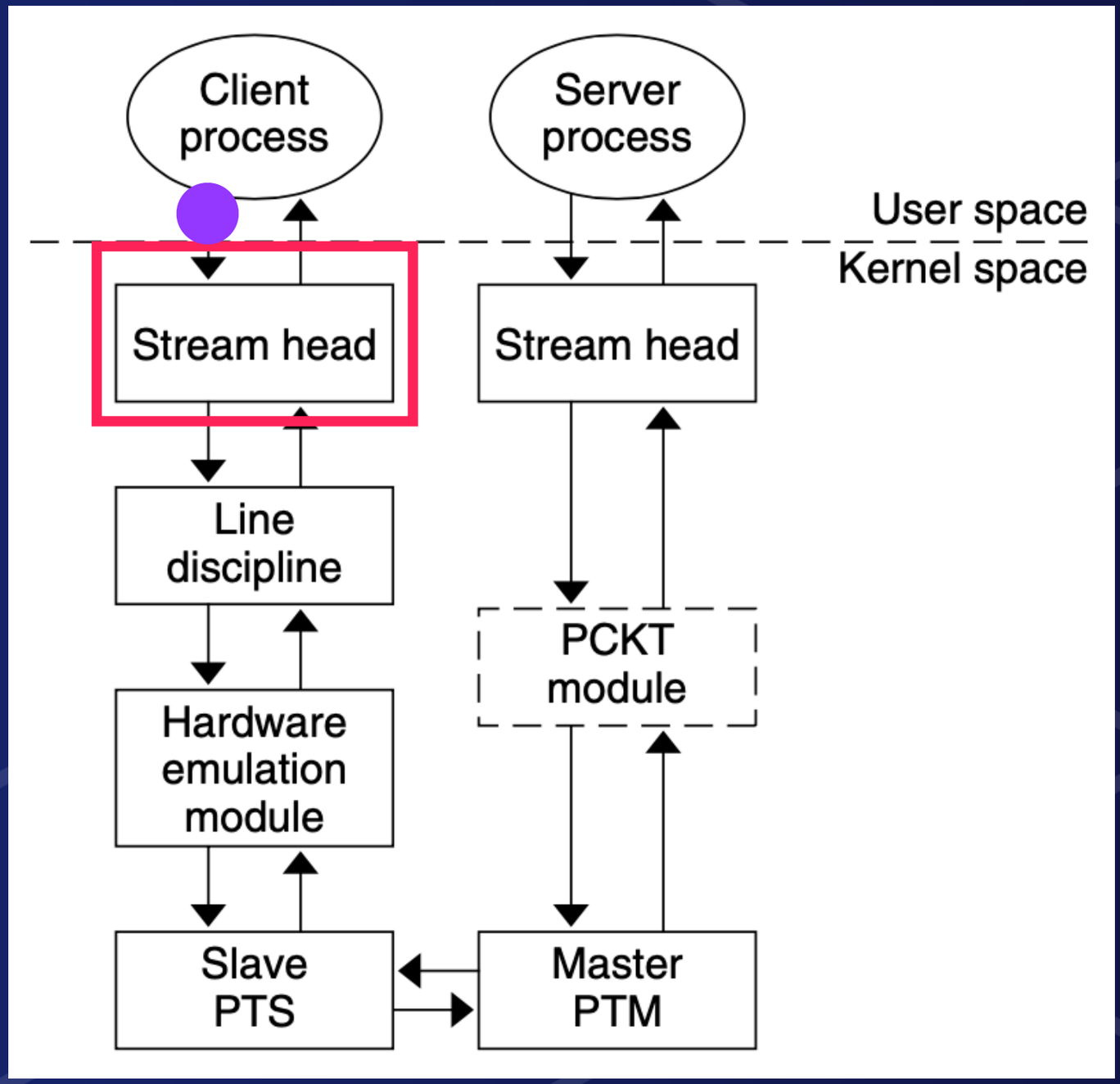

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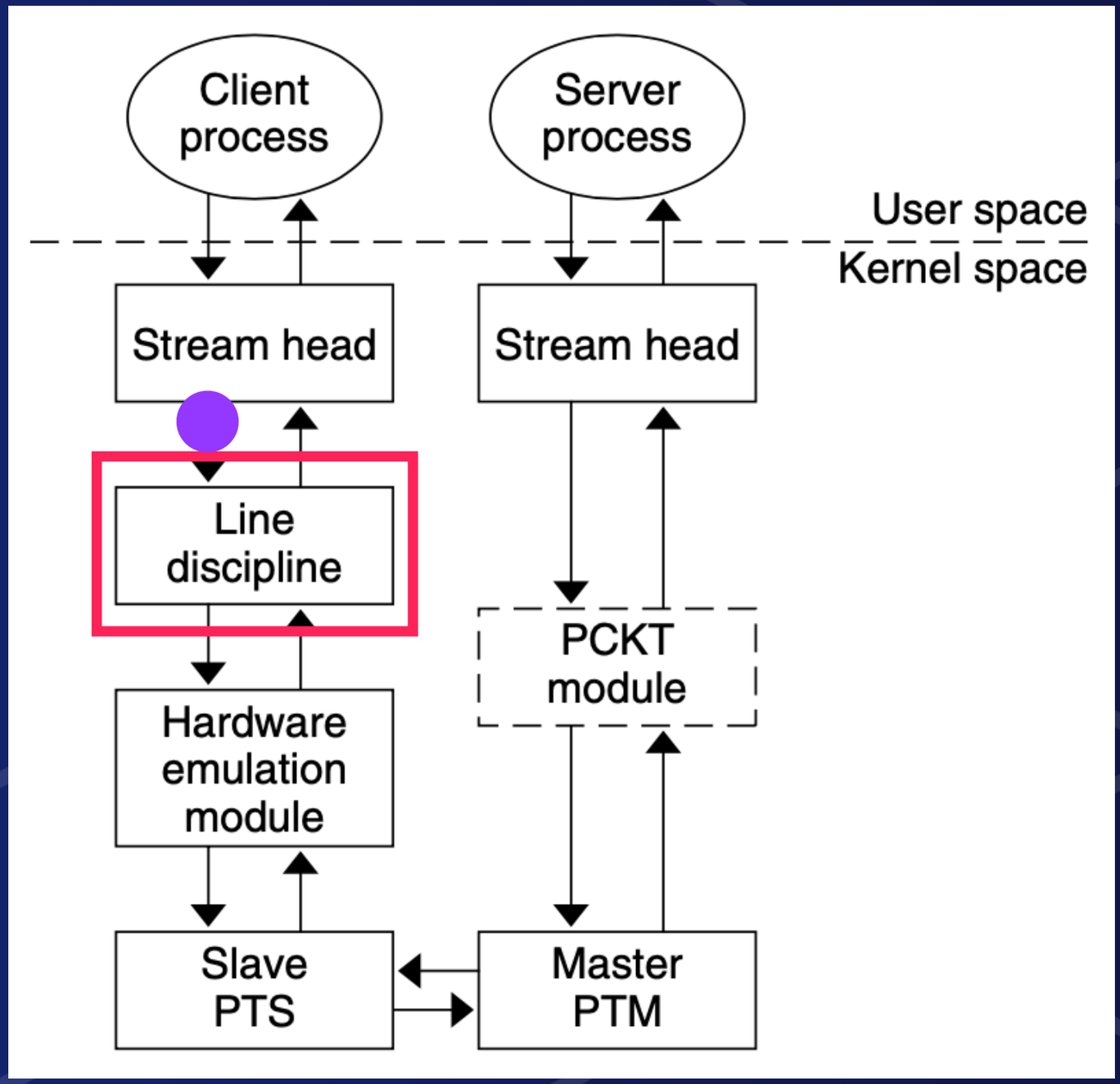

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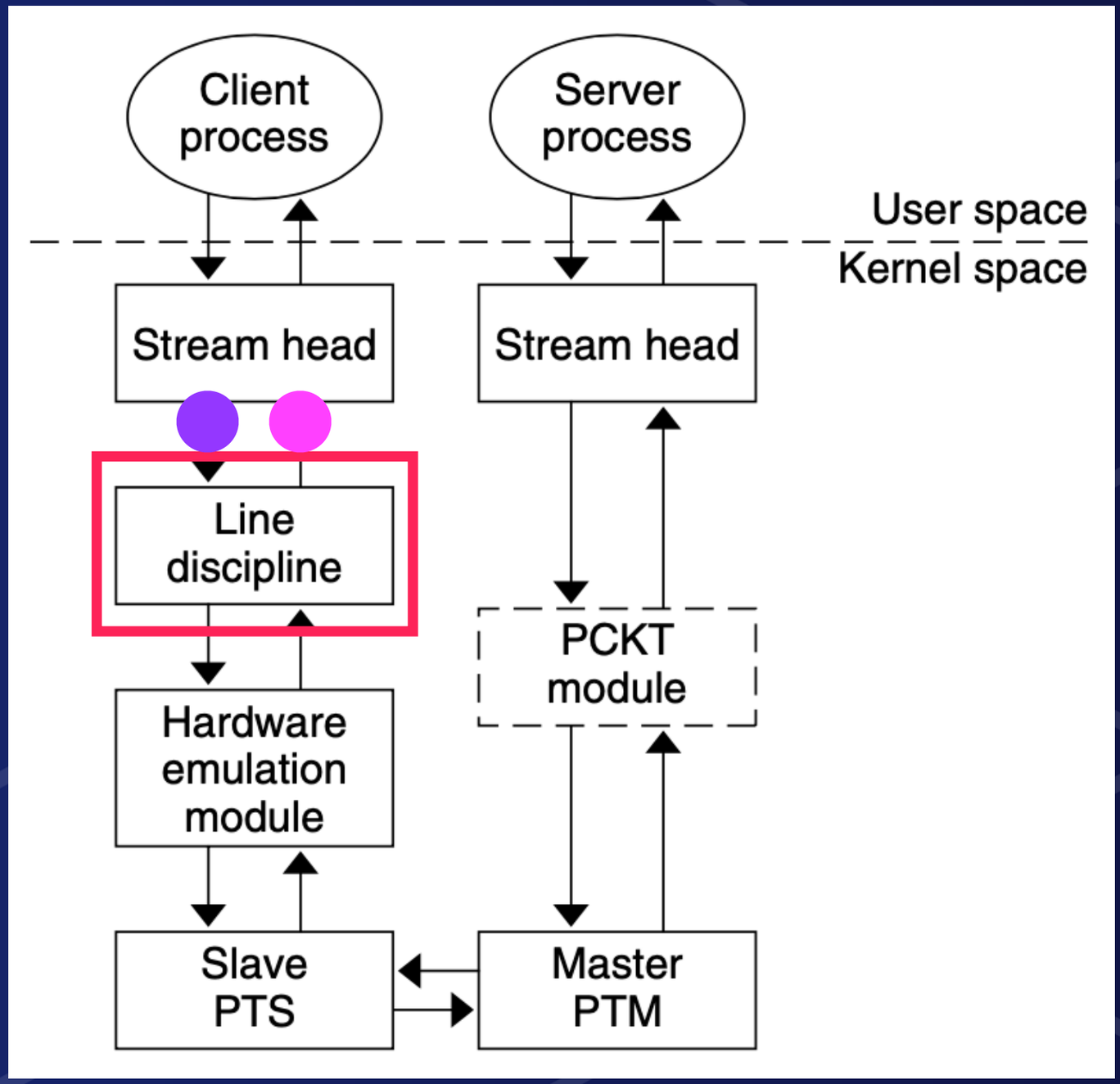

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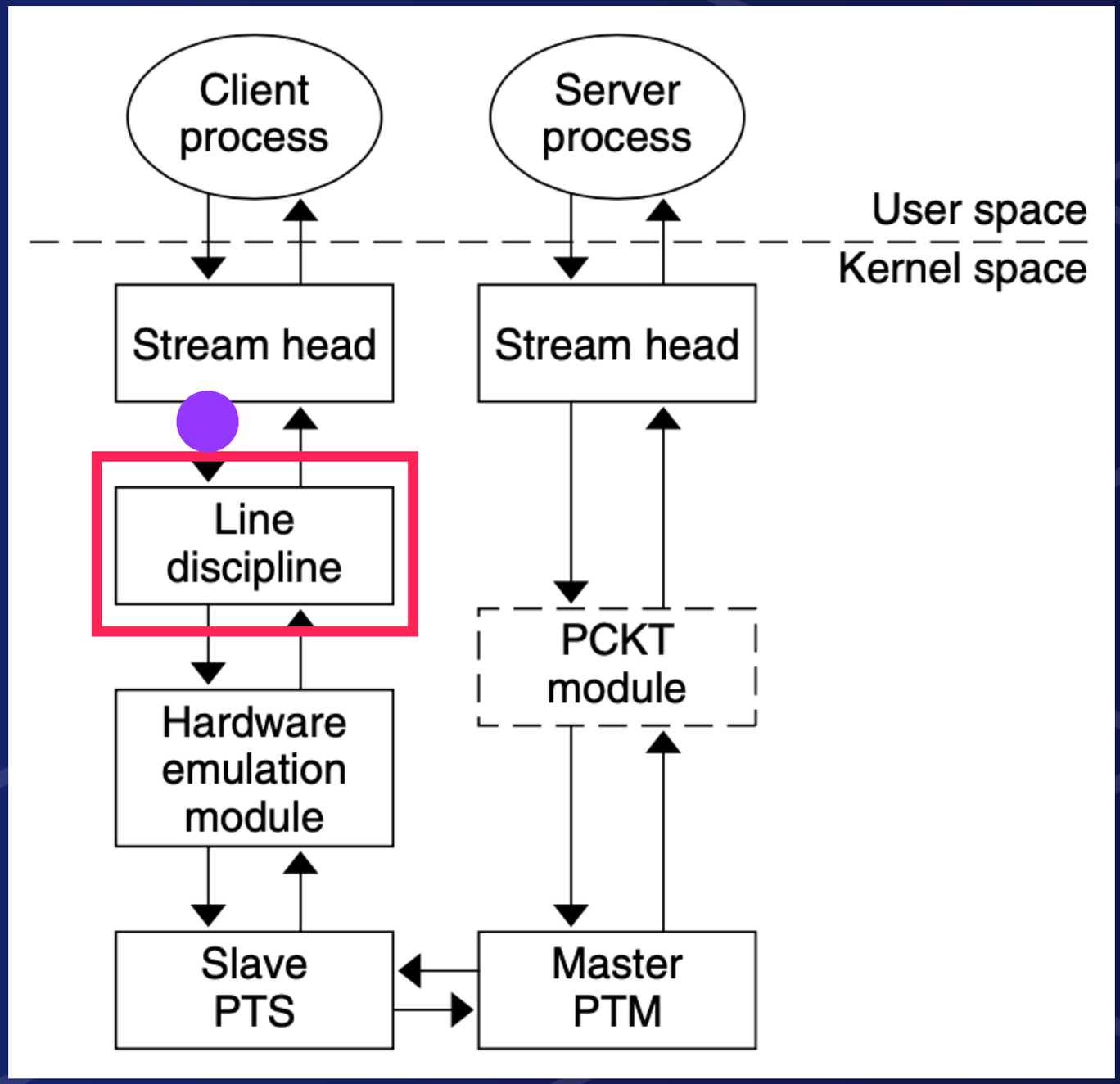

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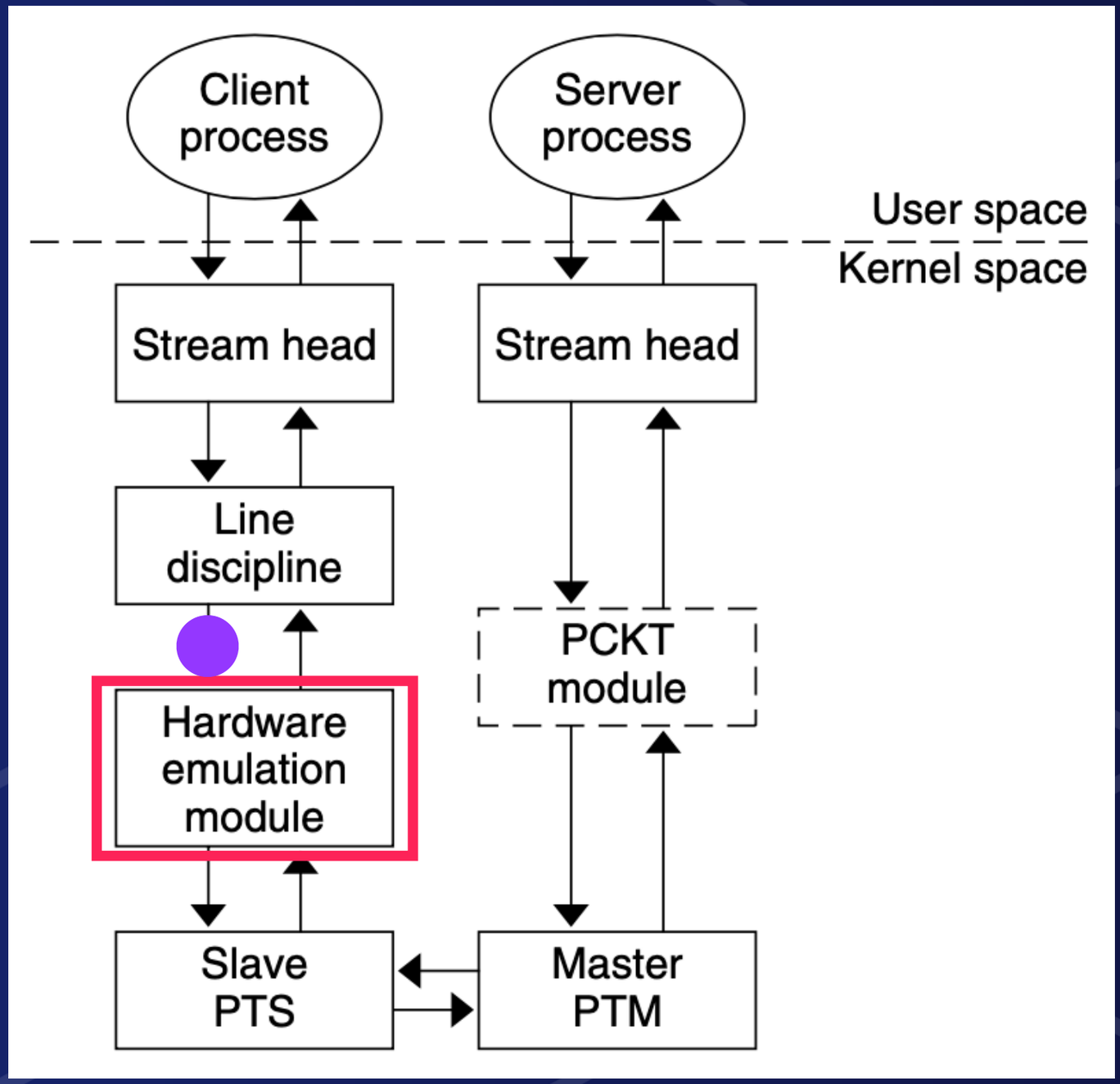

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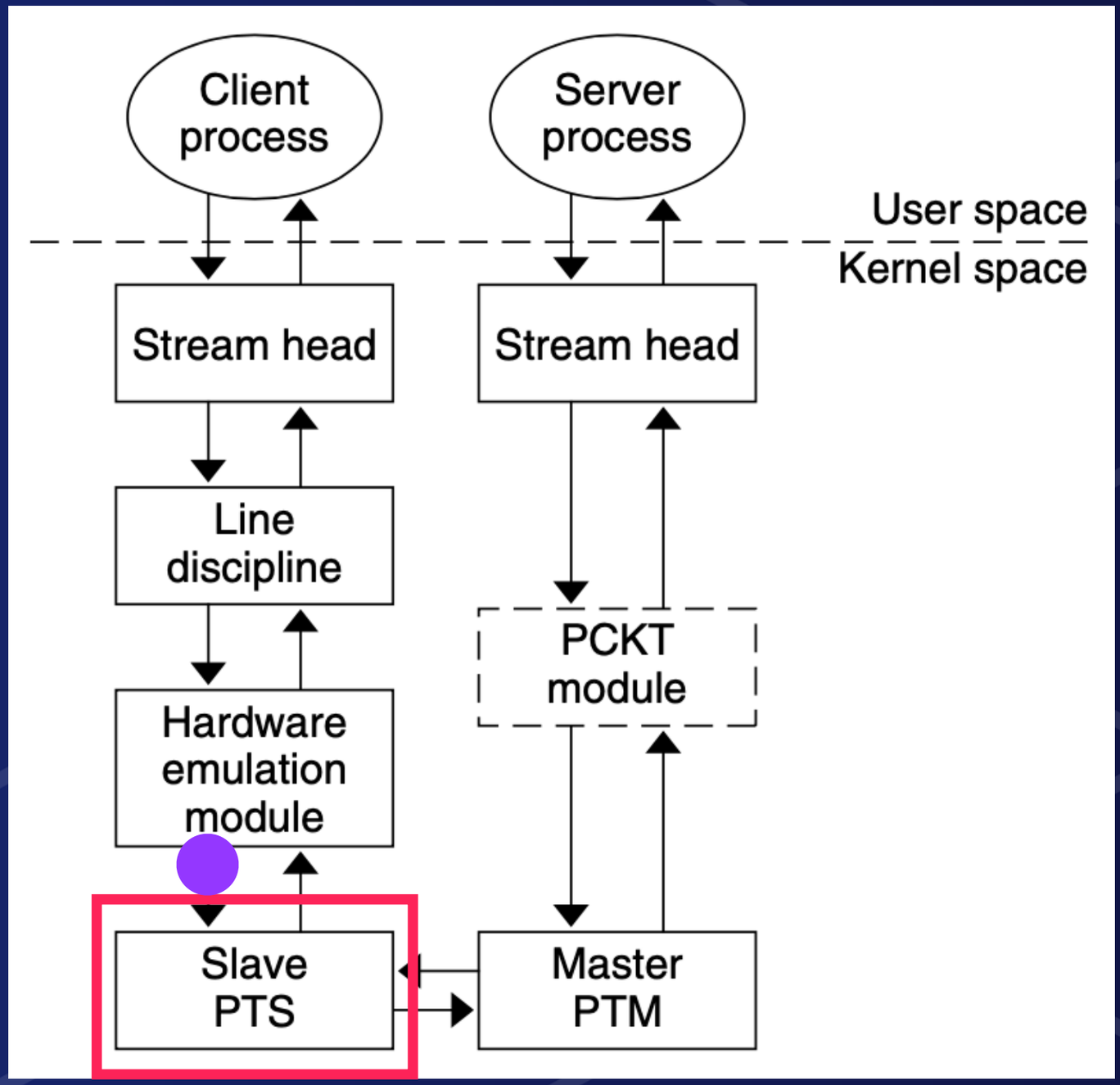

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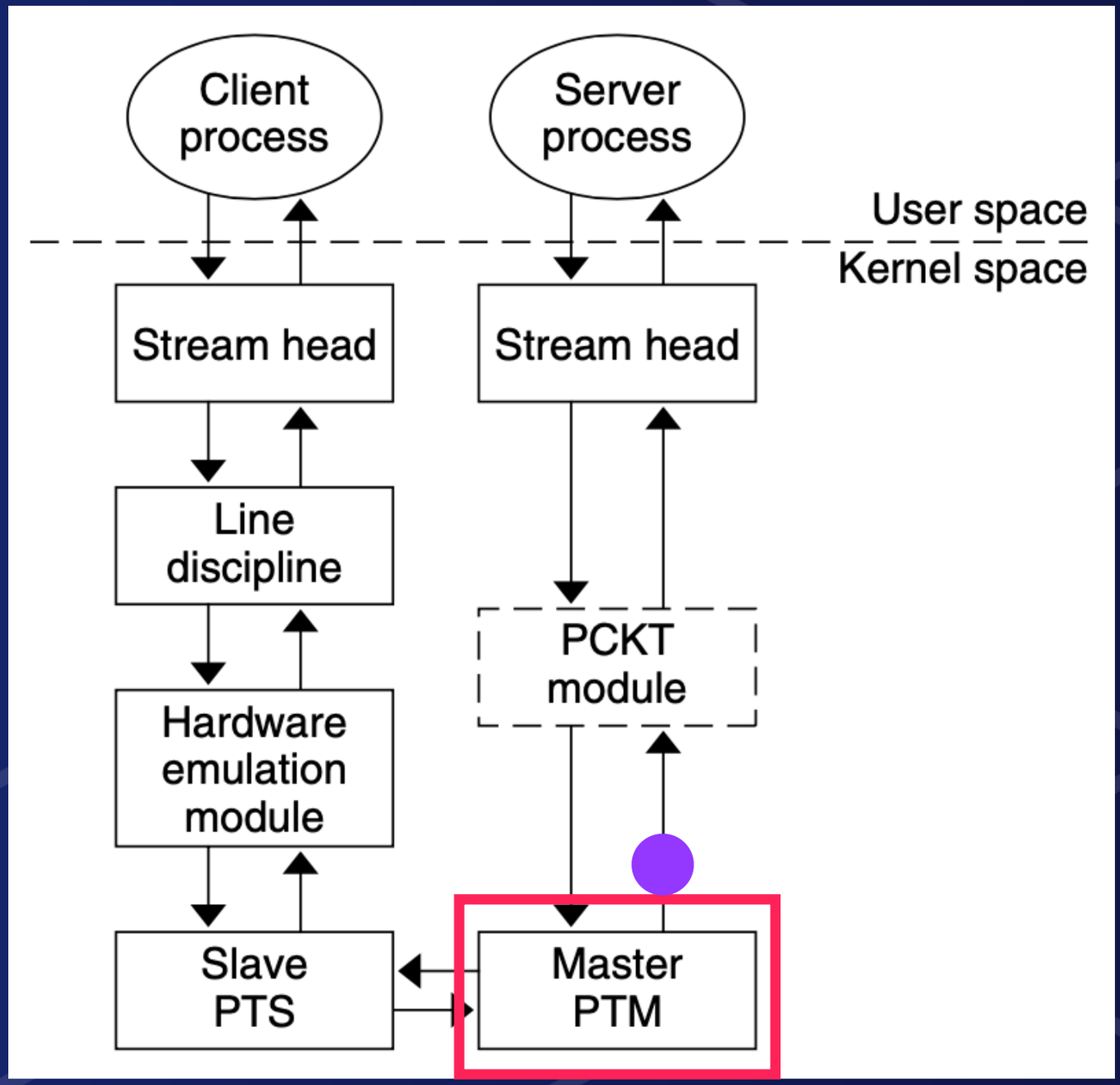

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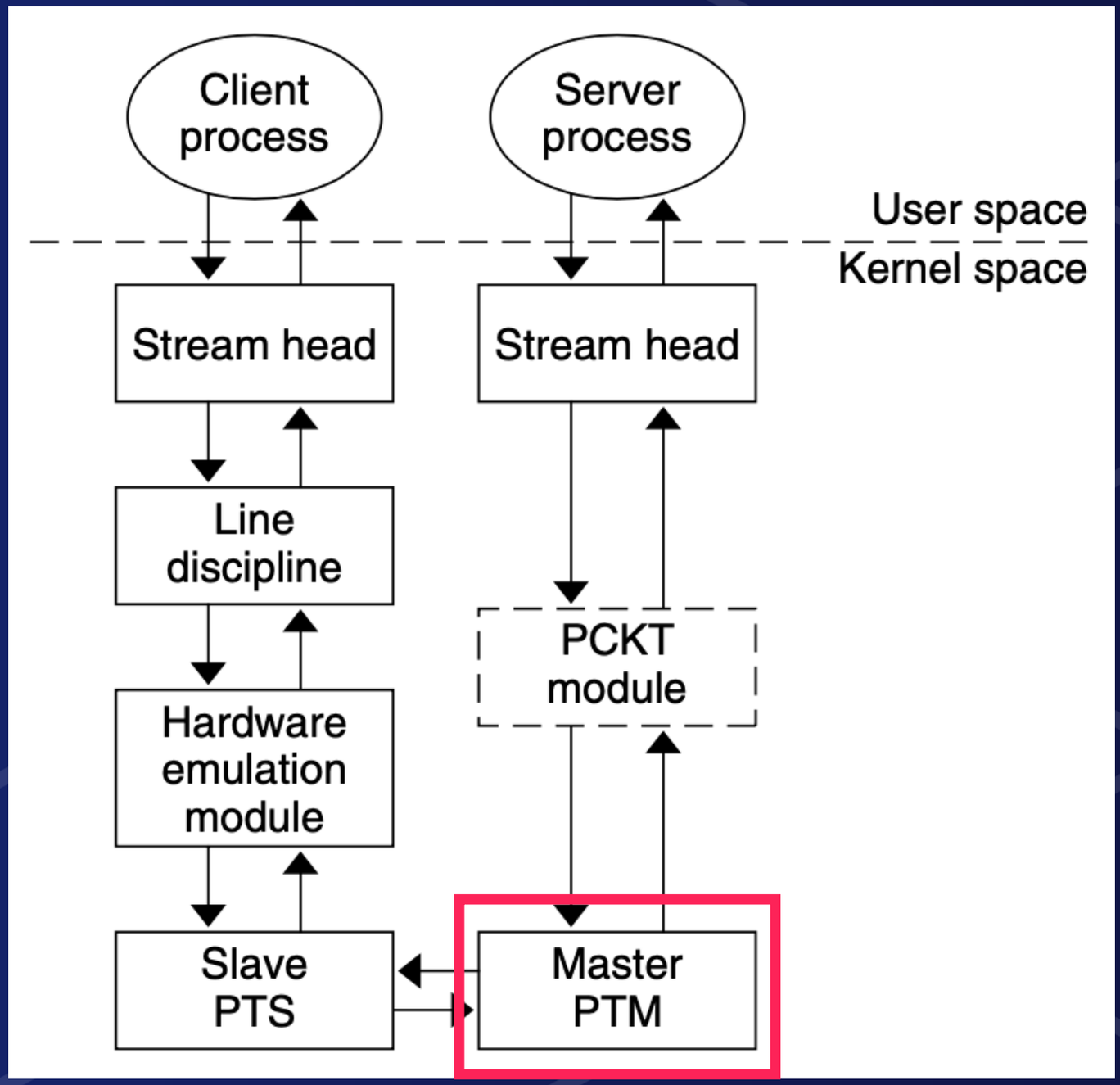
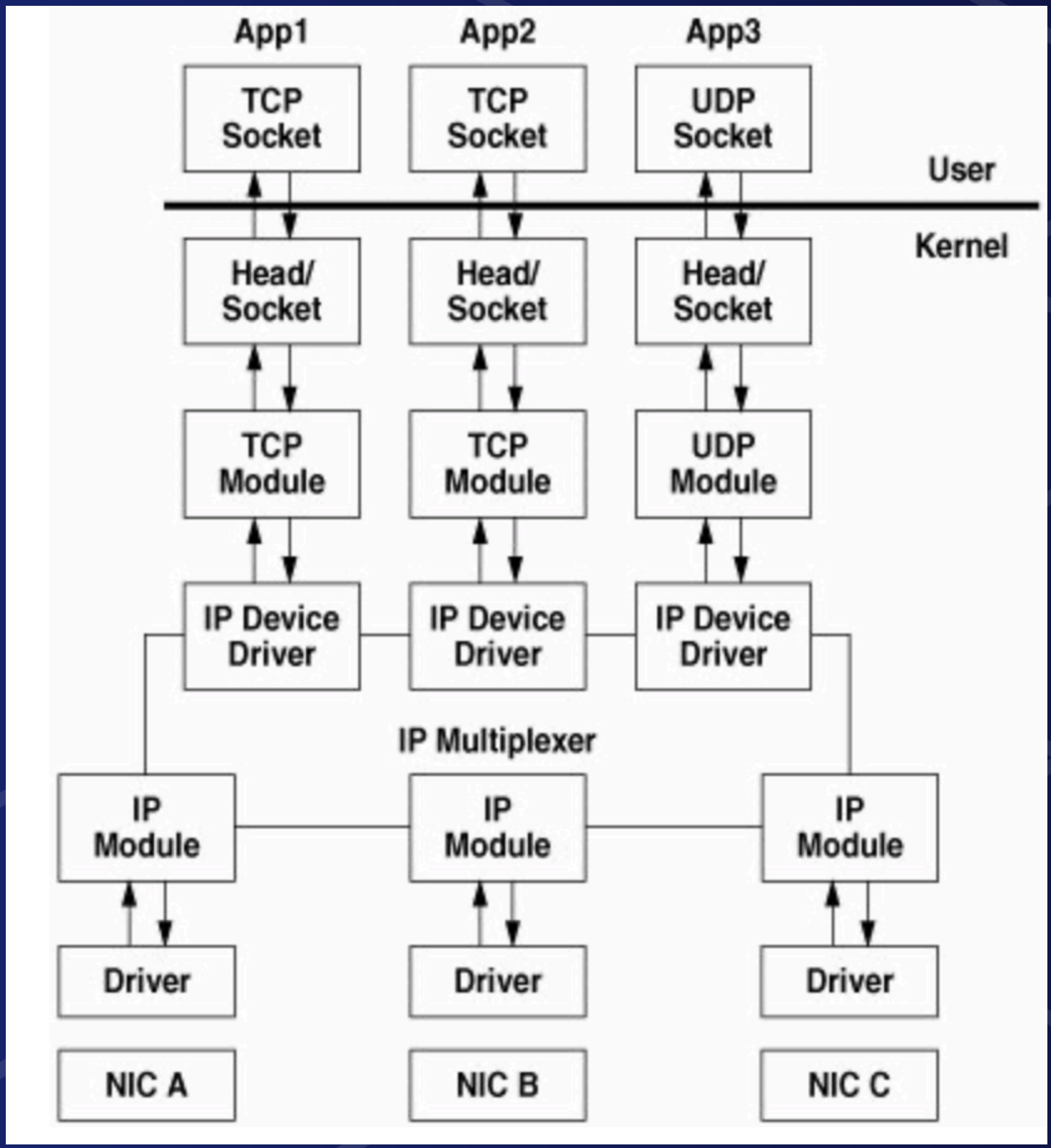


TCP/UDP in STREAMS



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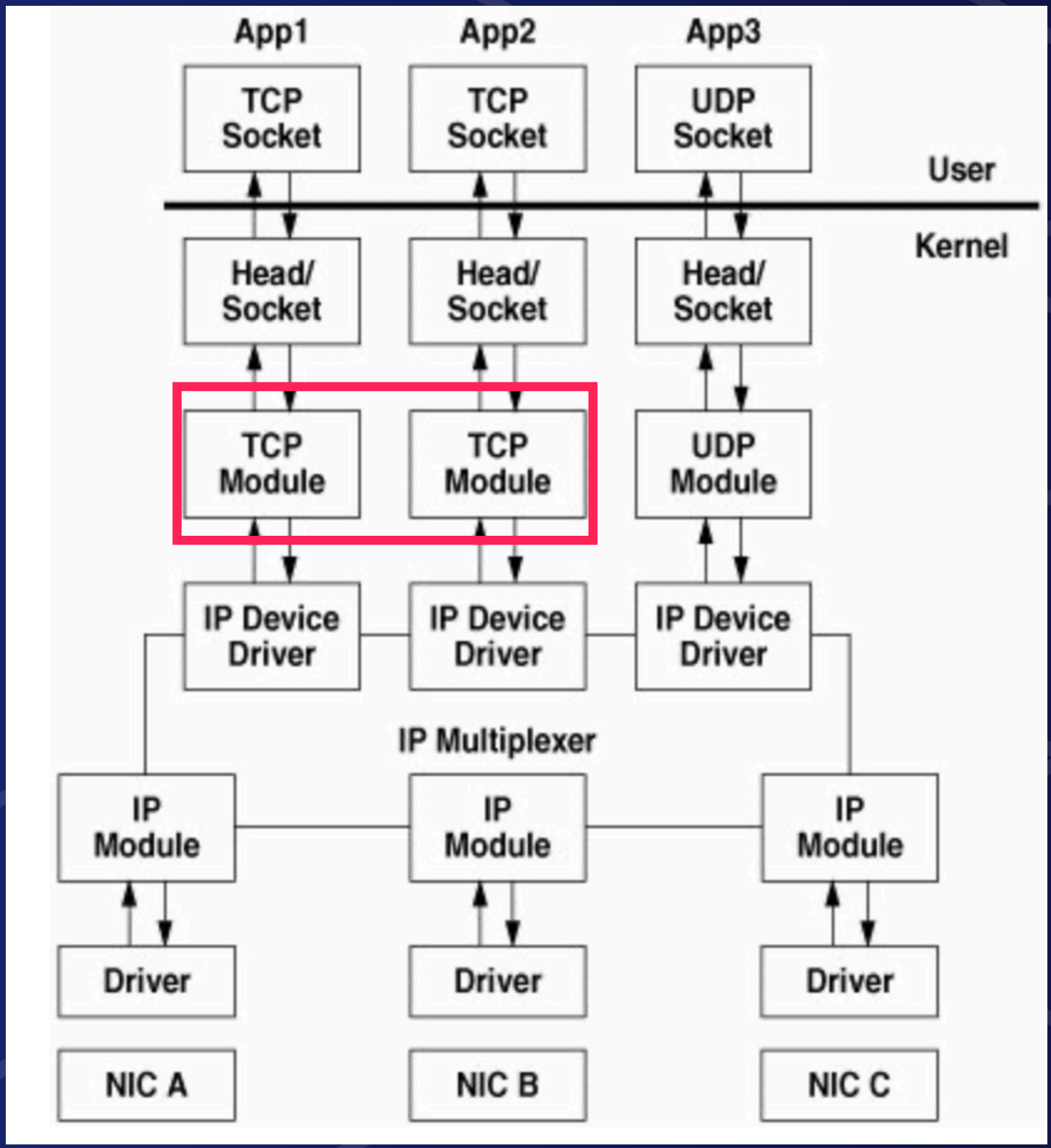

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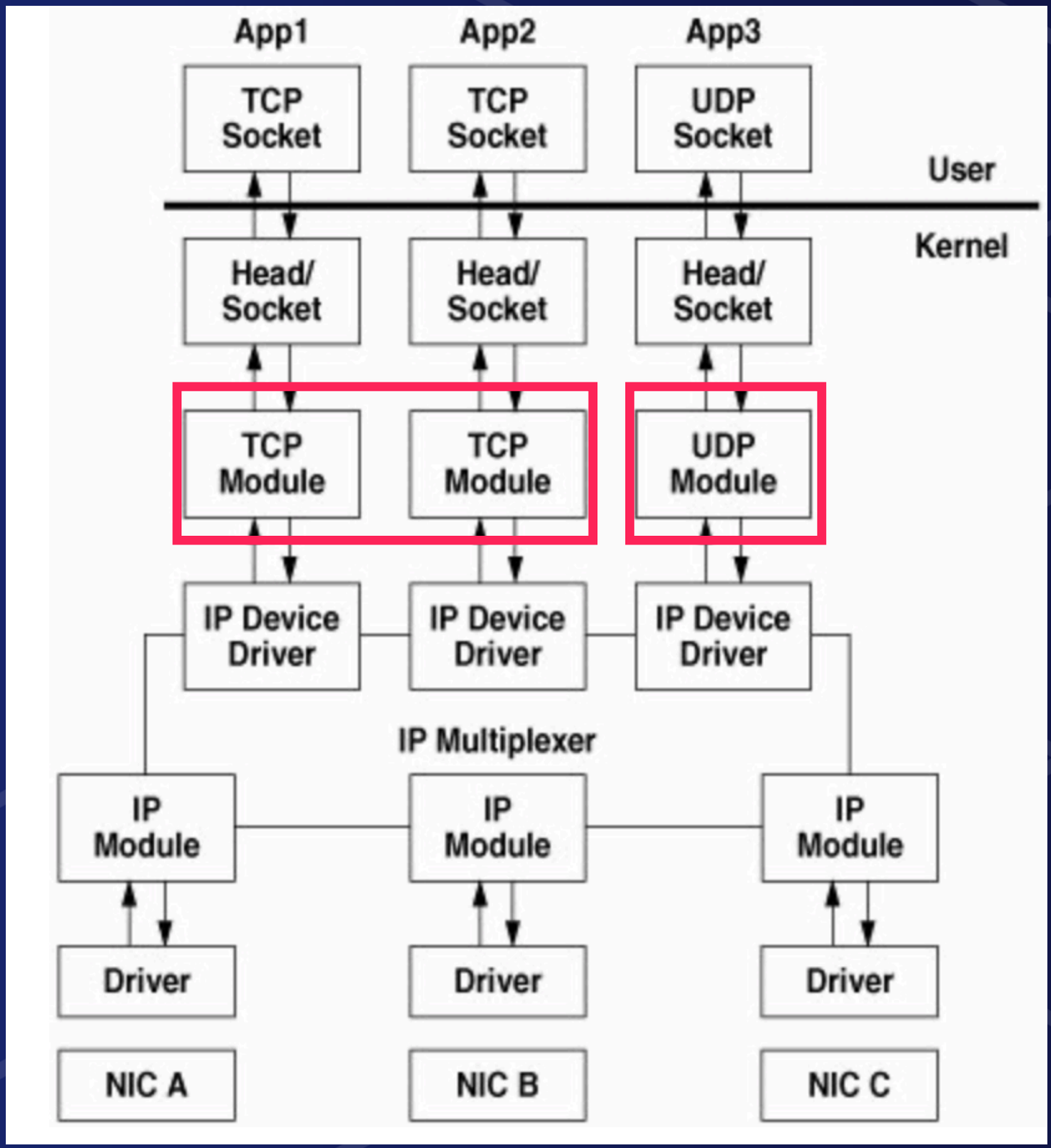

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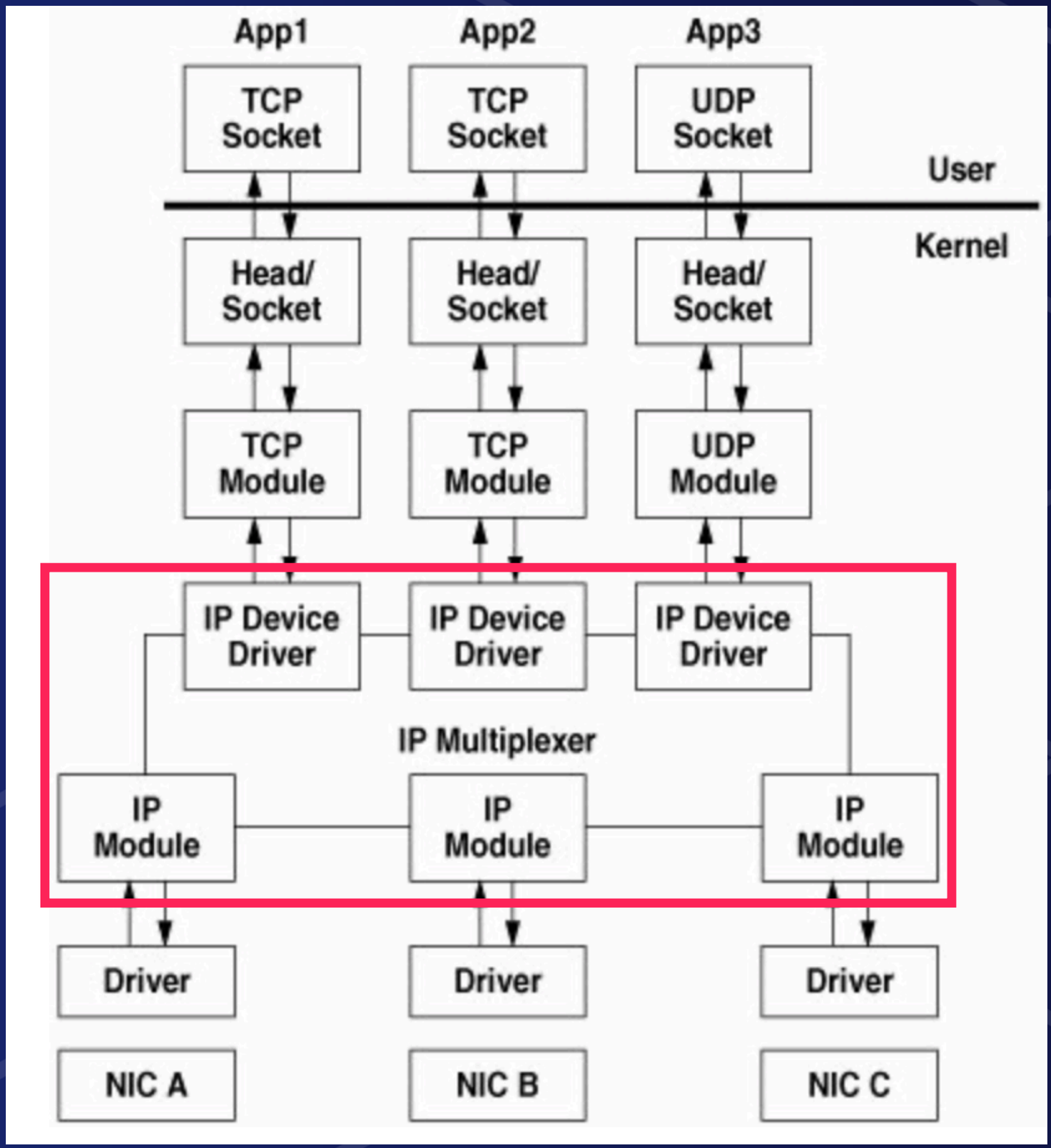

Reliability

Remember the library to intercept SYSV IPC?

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New requirement - reliability

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Multiple network cards

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Use available network cards to recovery from failures

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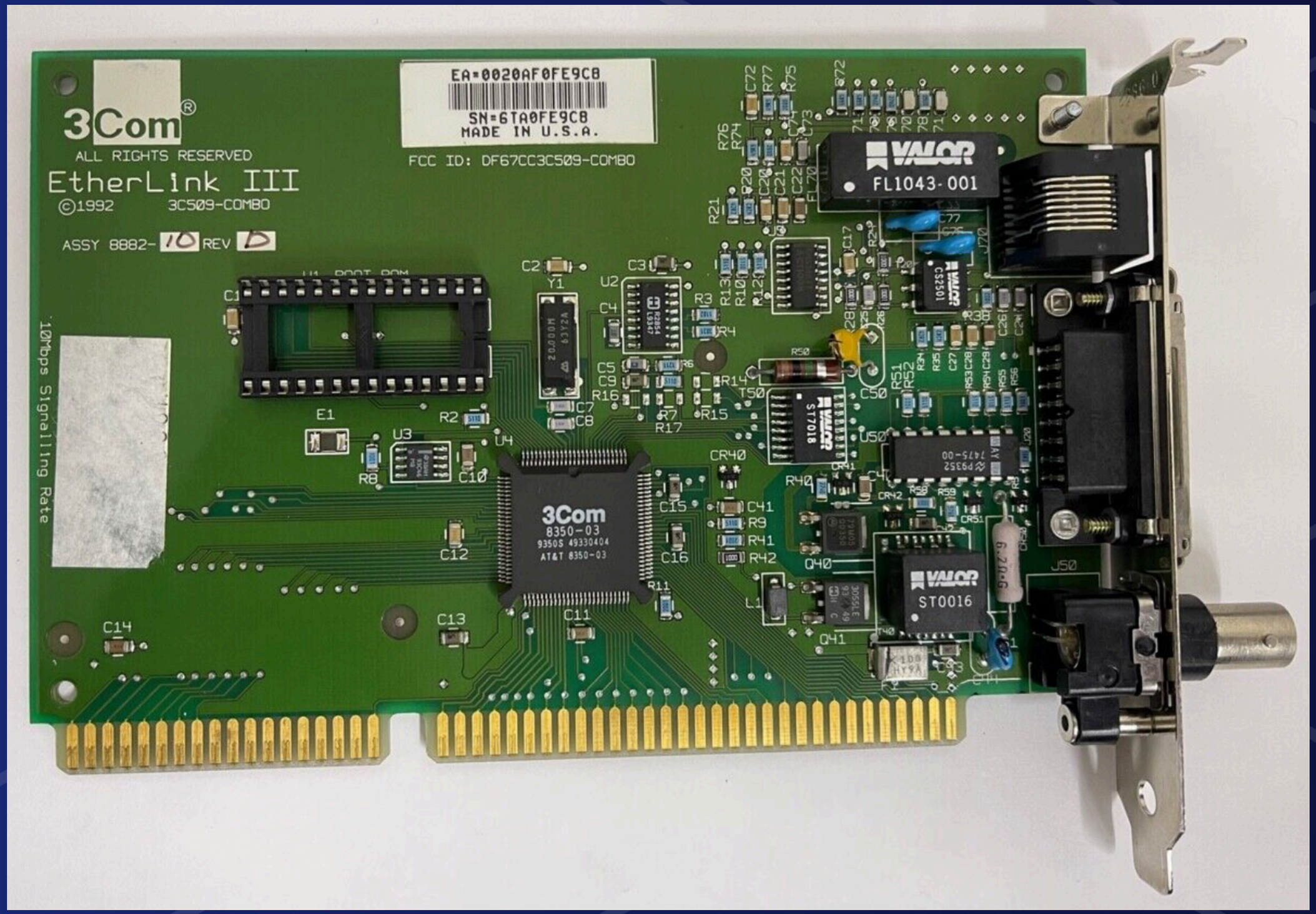

3COM ETHERLINK III

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dcom.a

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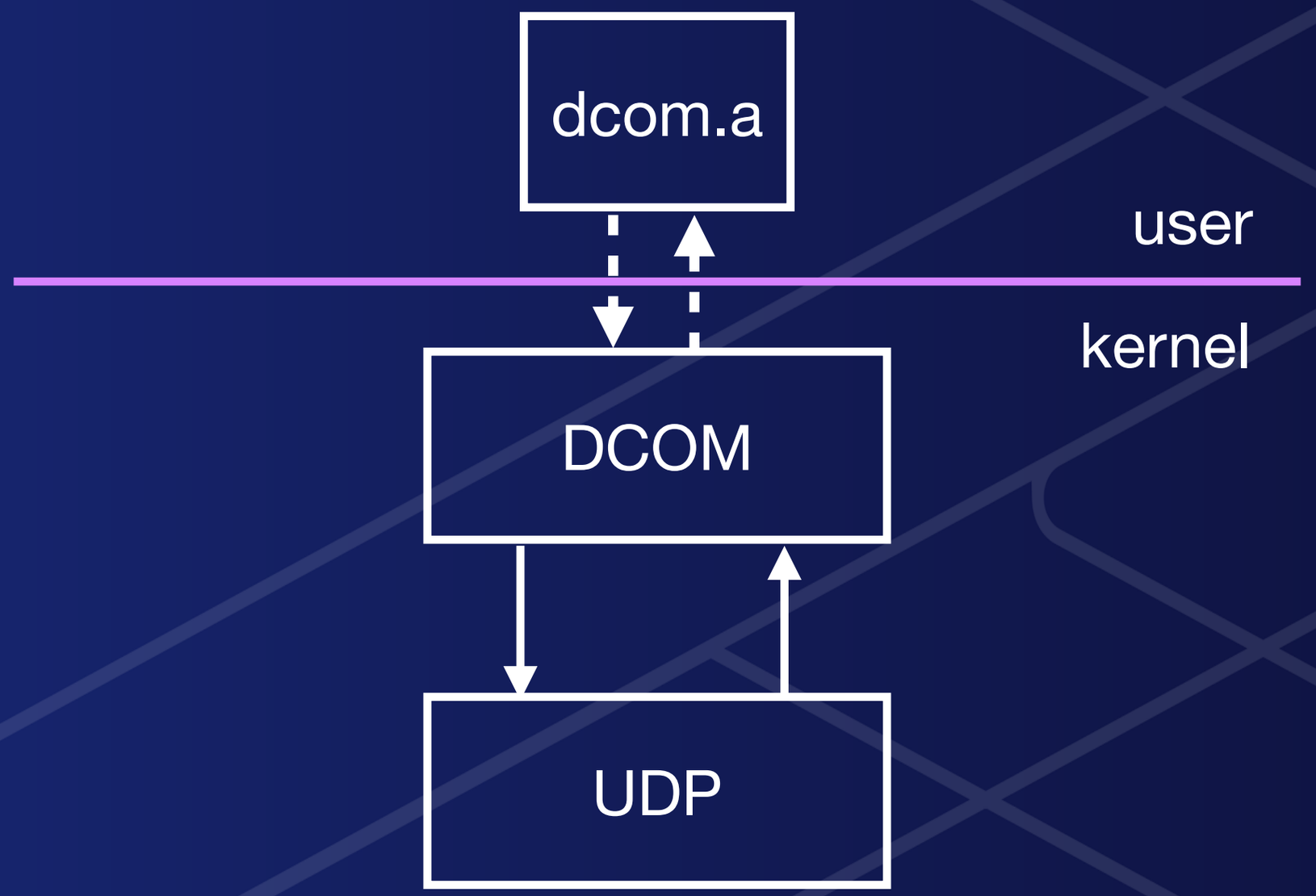

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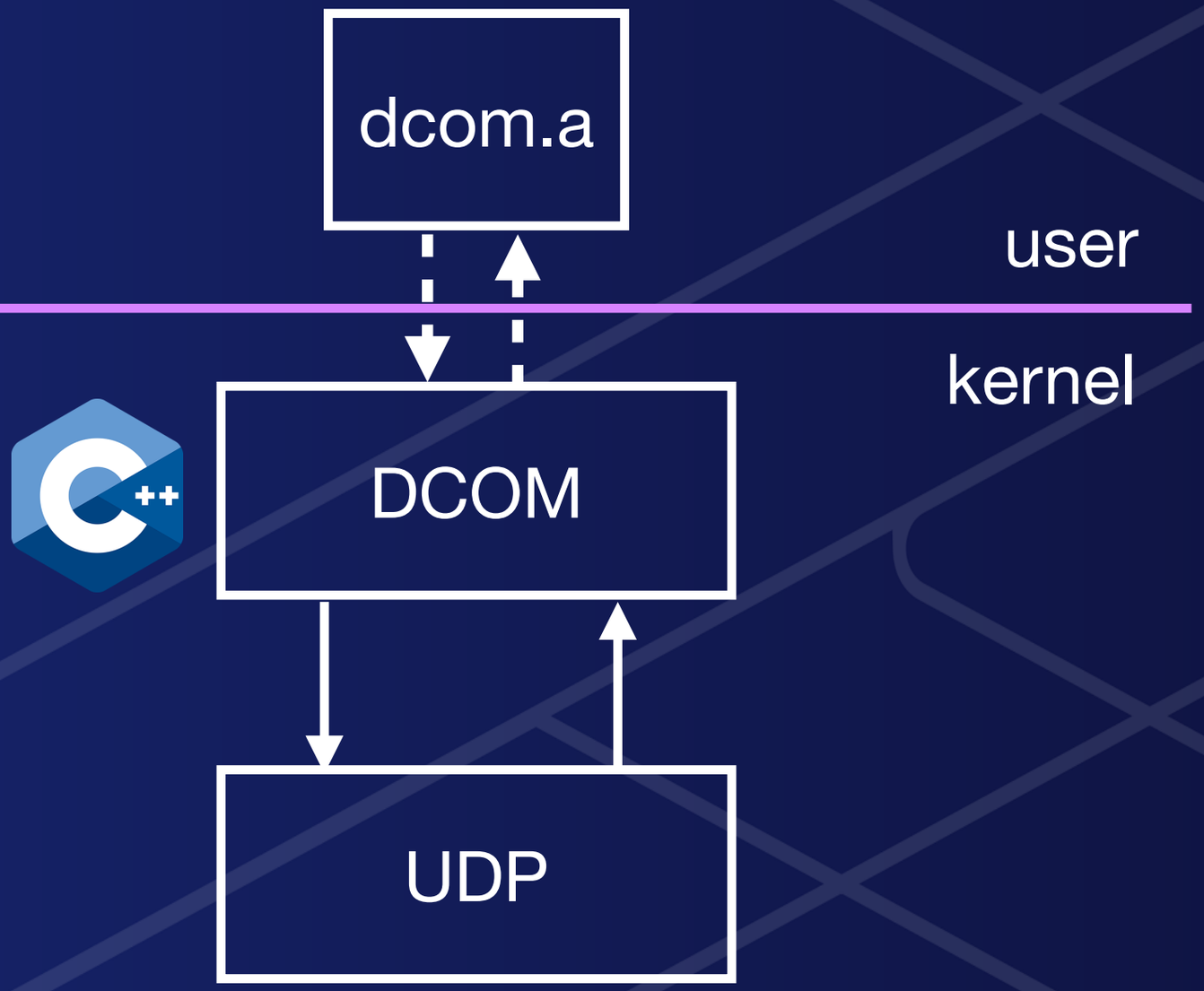

Me and C++ and STREAMS Sitting in a Tree

https://www.youtube.com/watch?v=Pd0VBm8gU5o

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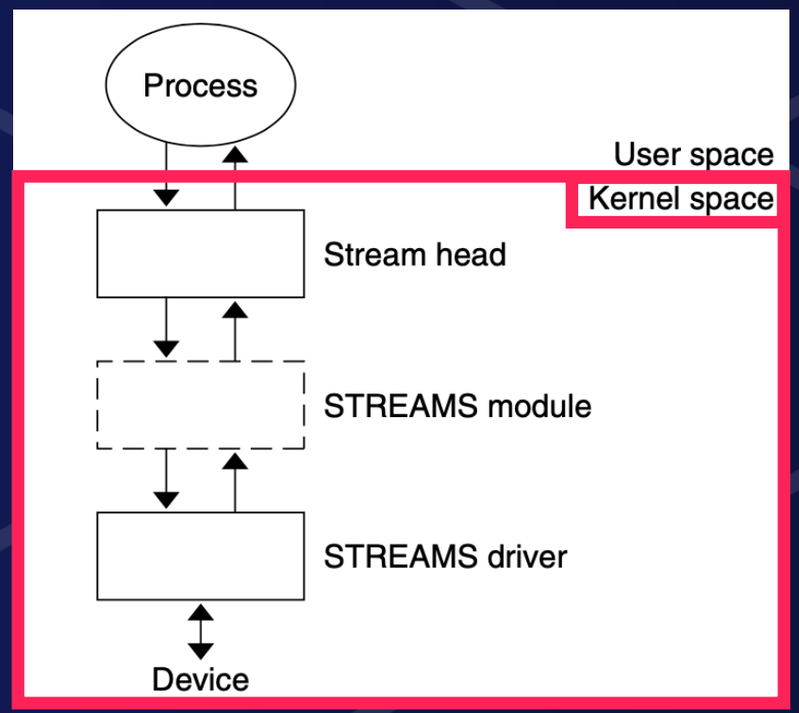

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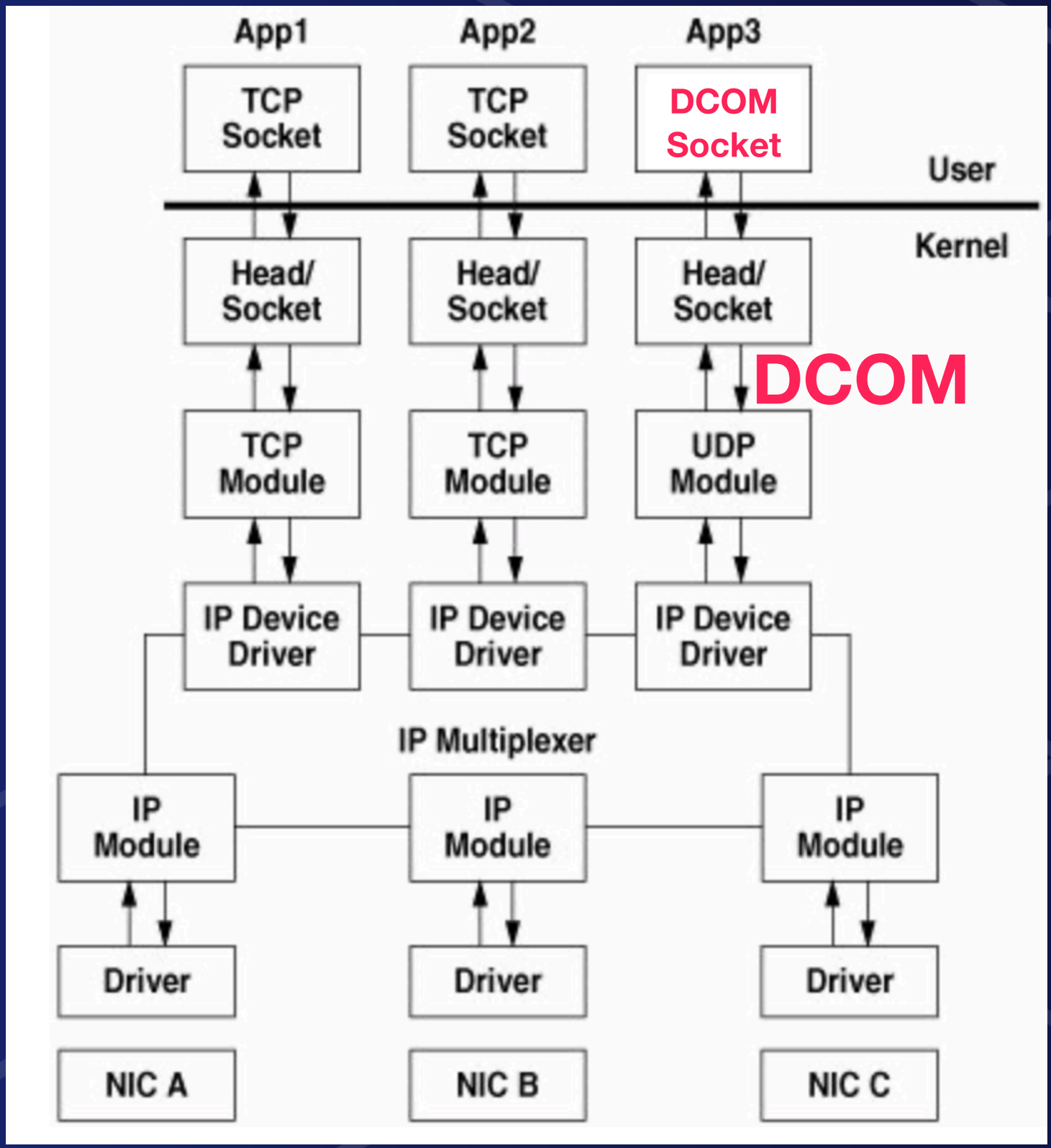

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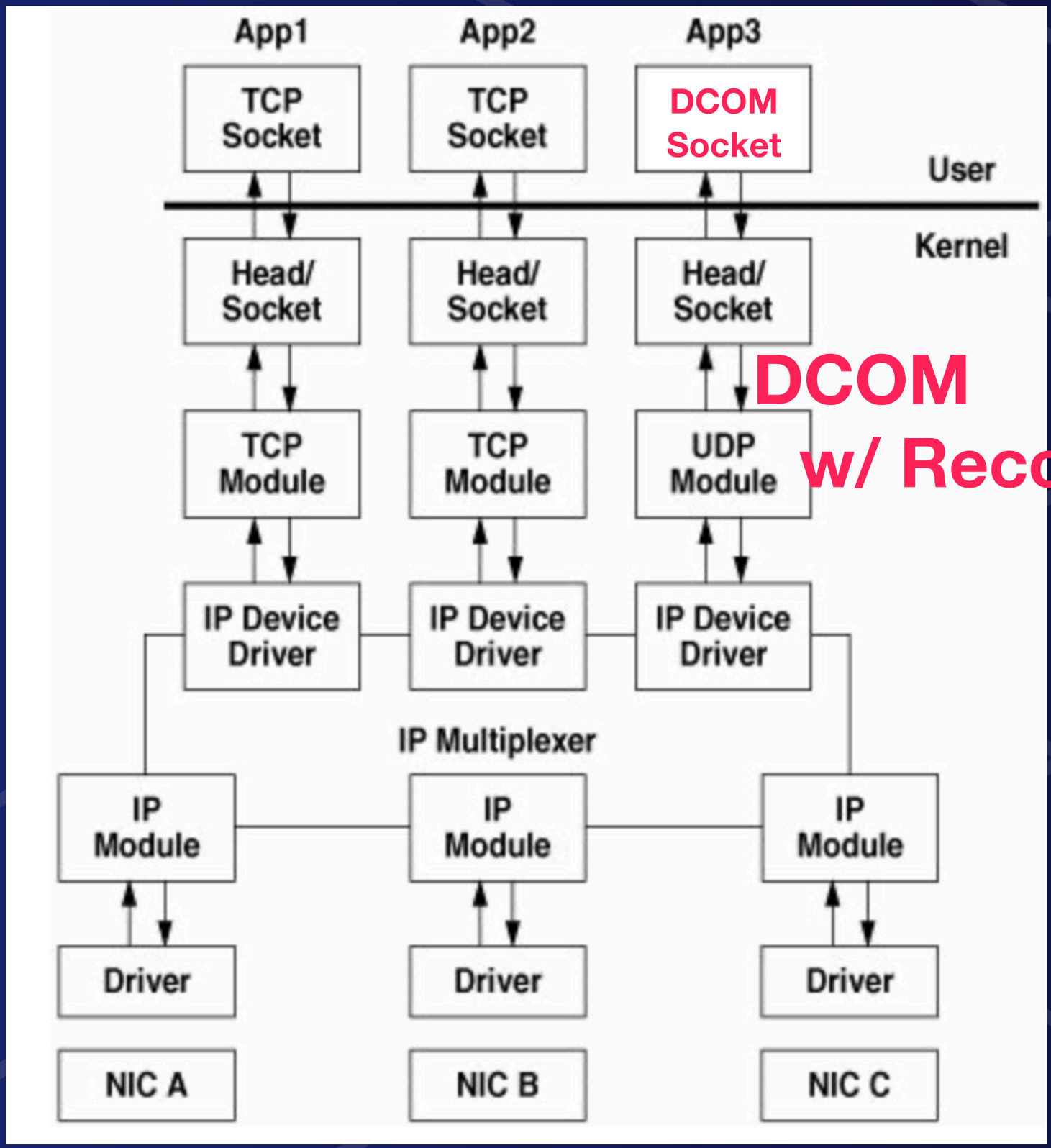
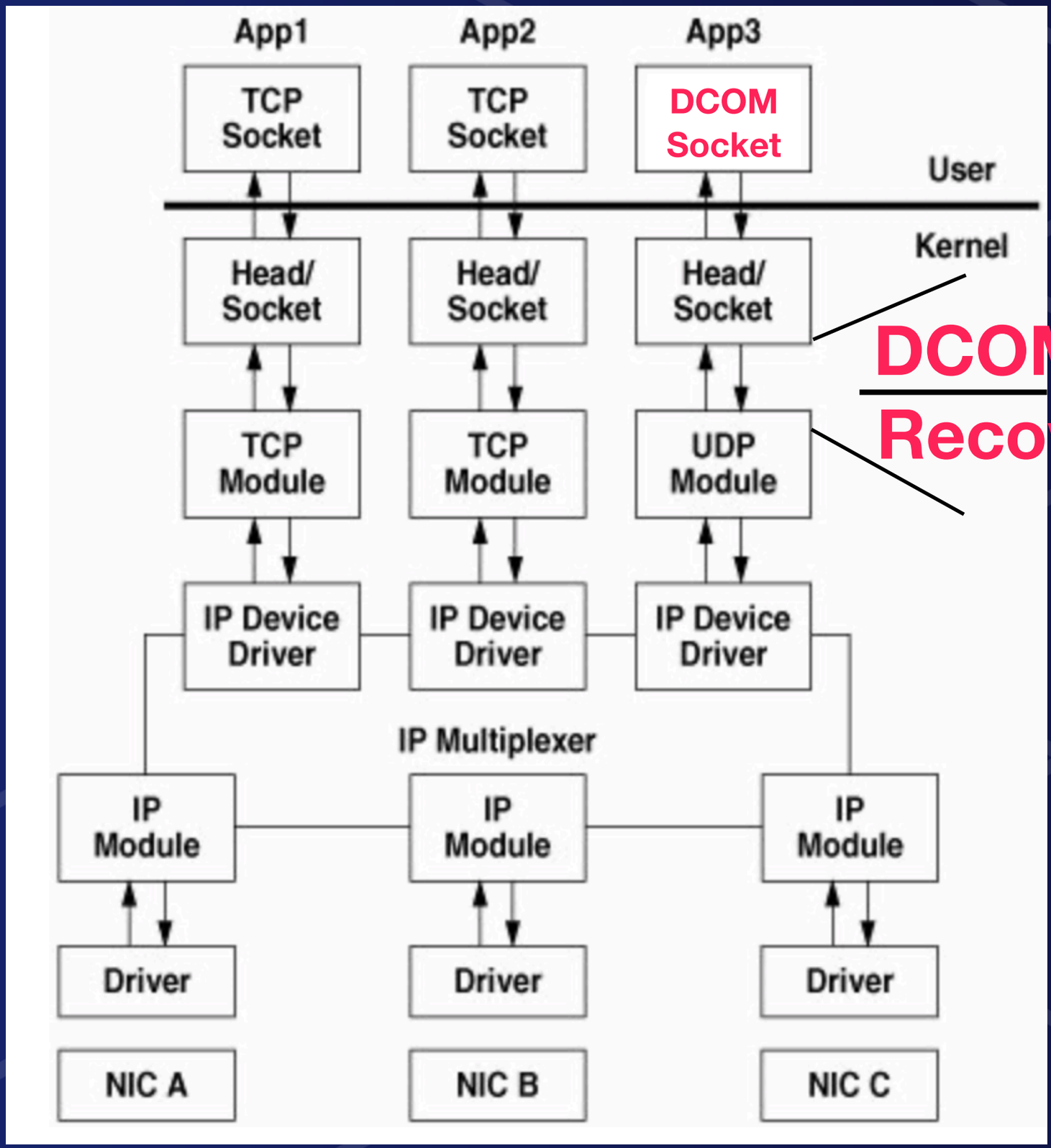


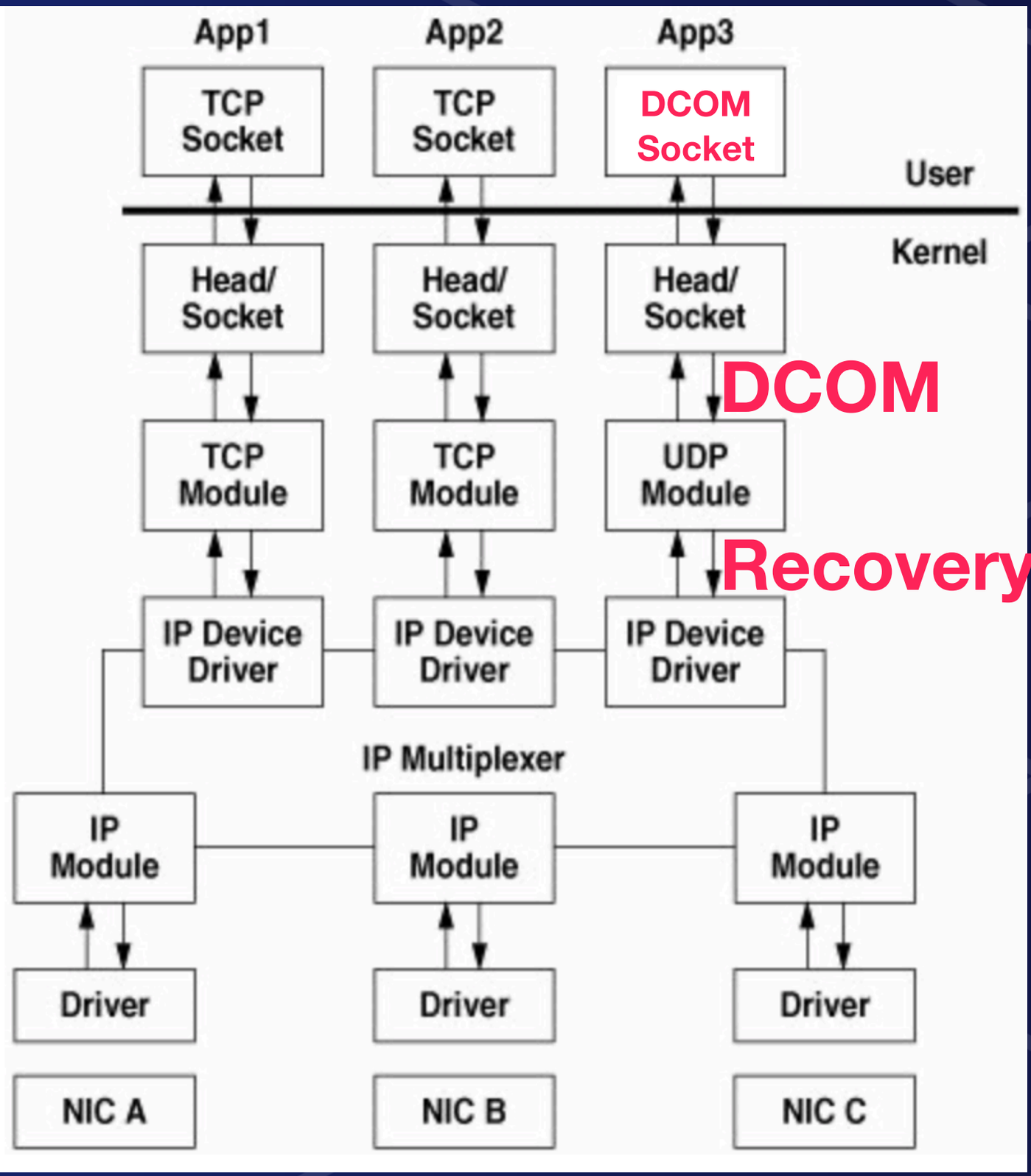
DCOM w/ Recovery

Reliability



DCOM Recovery

Reliability



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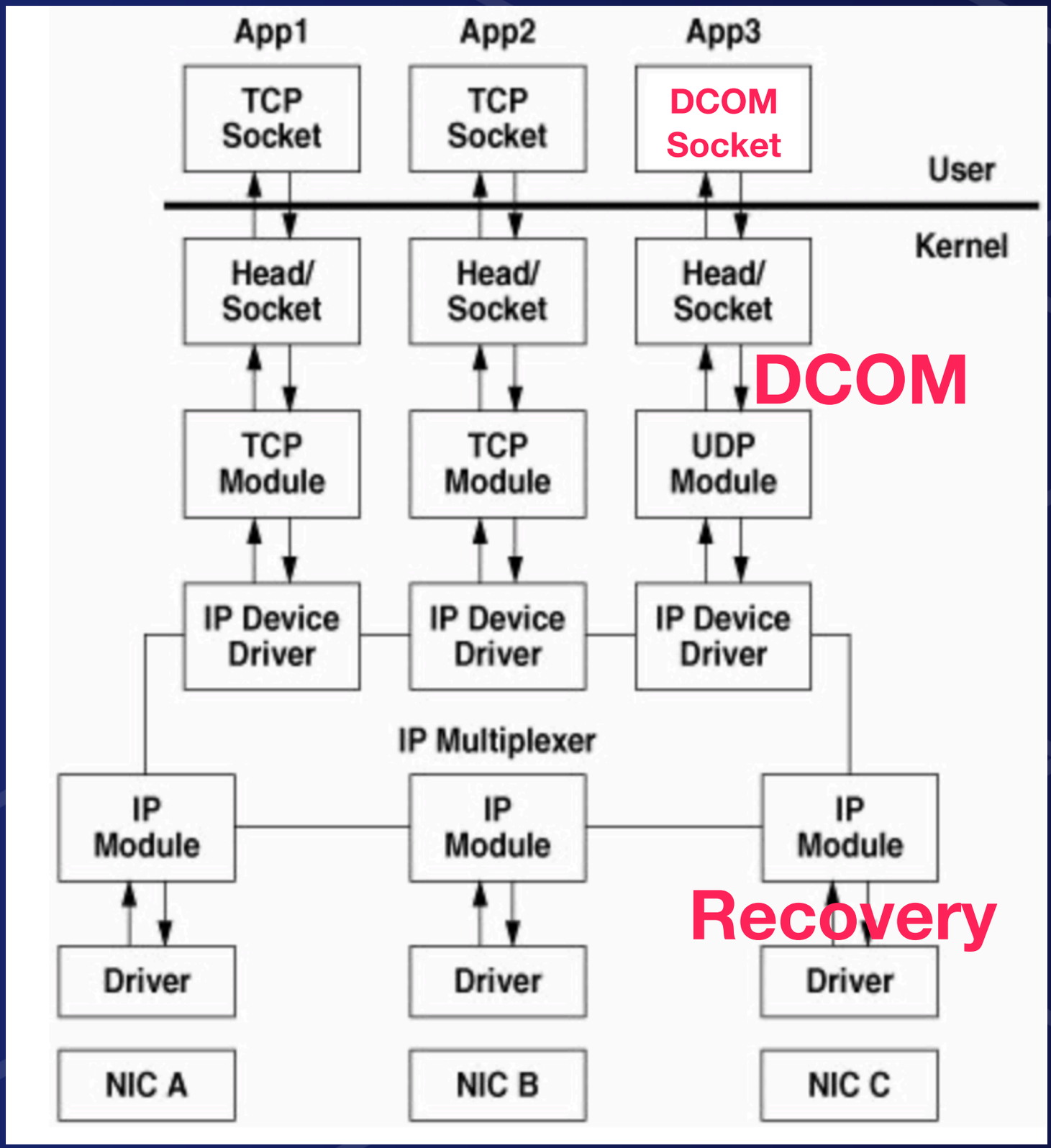

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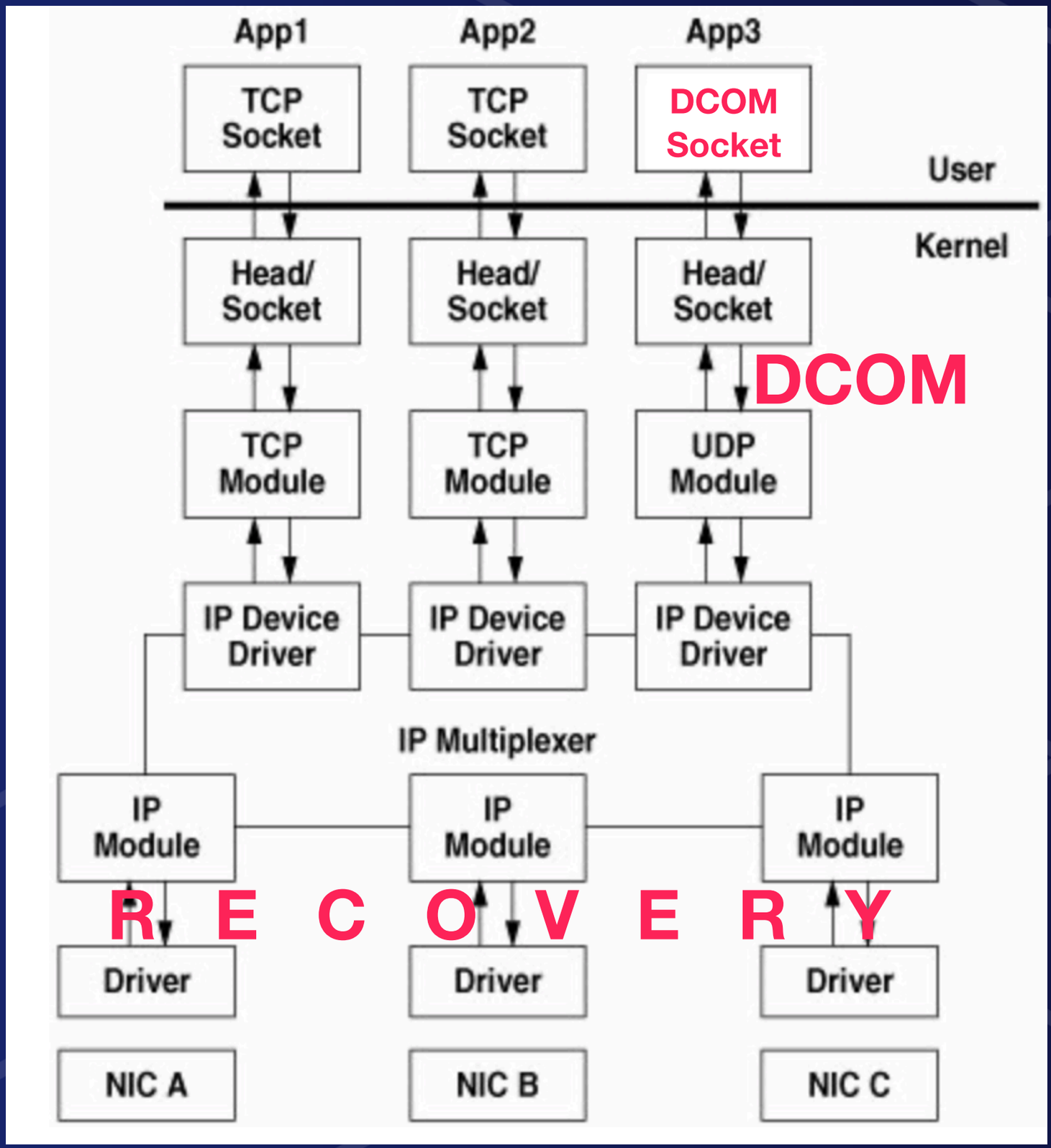

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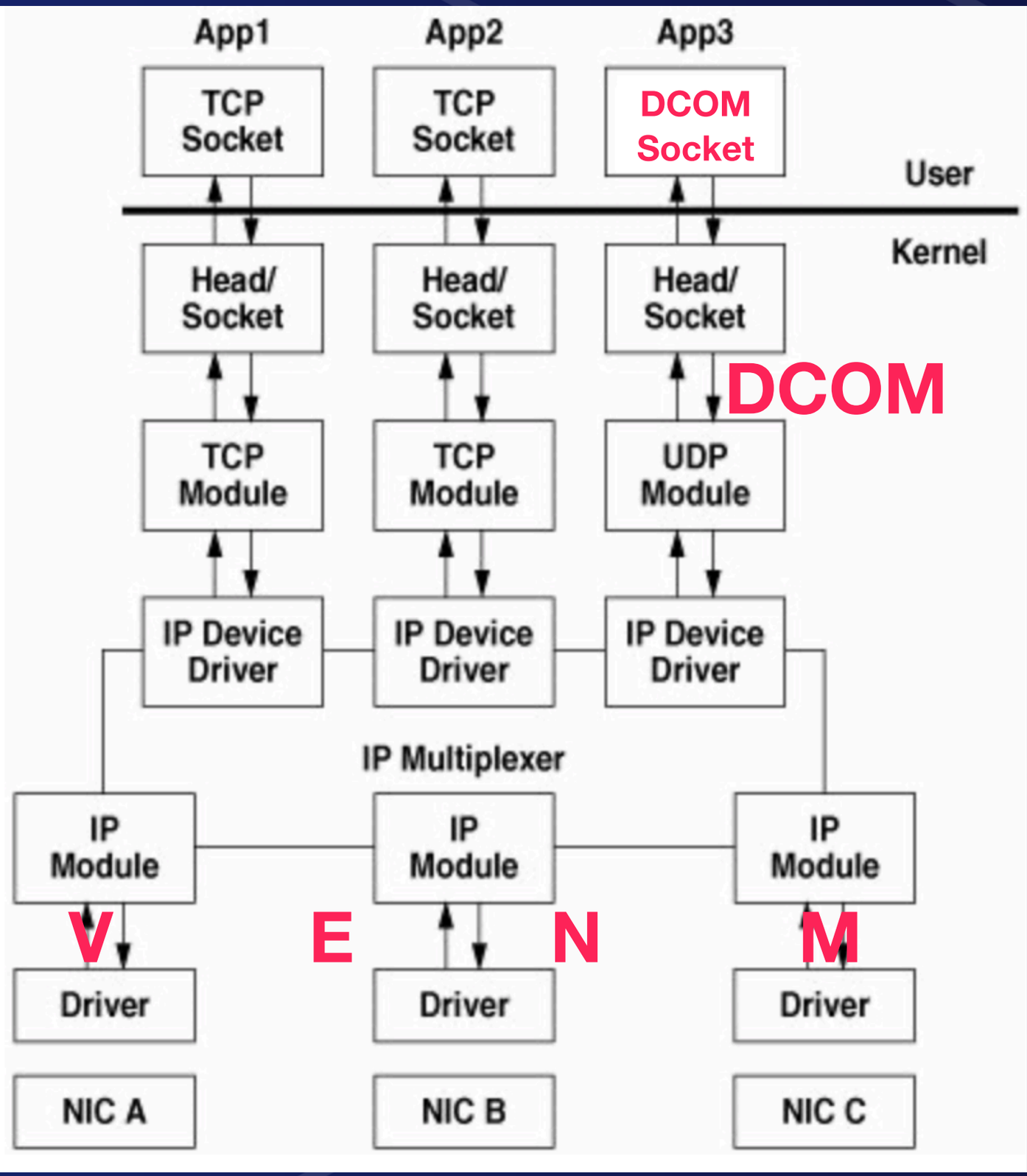

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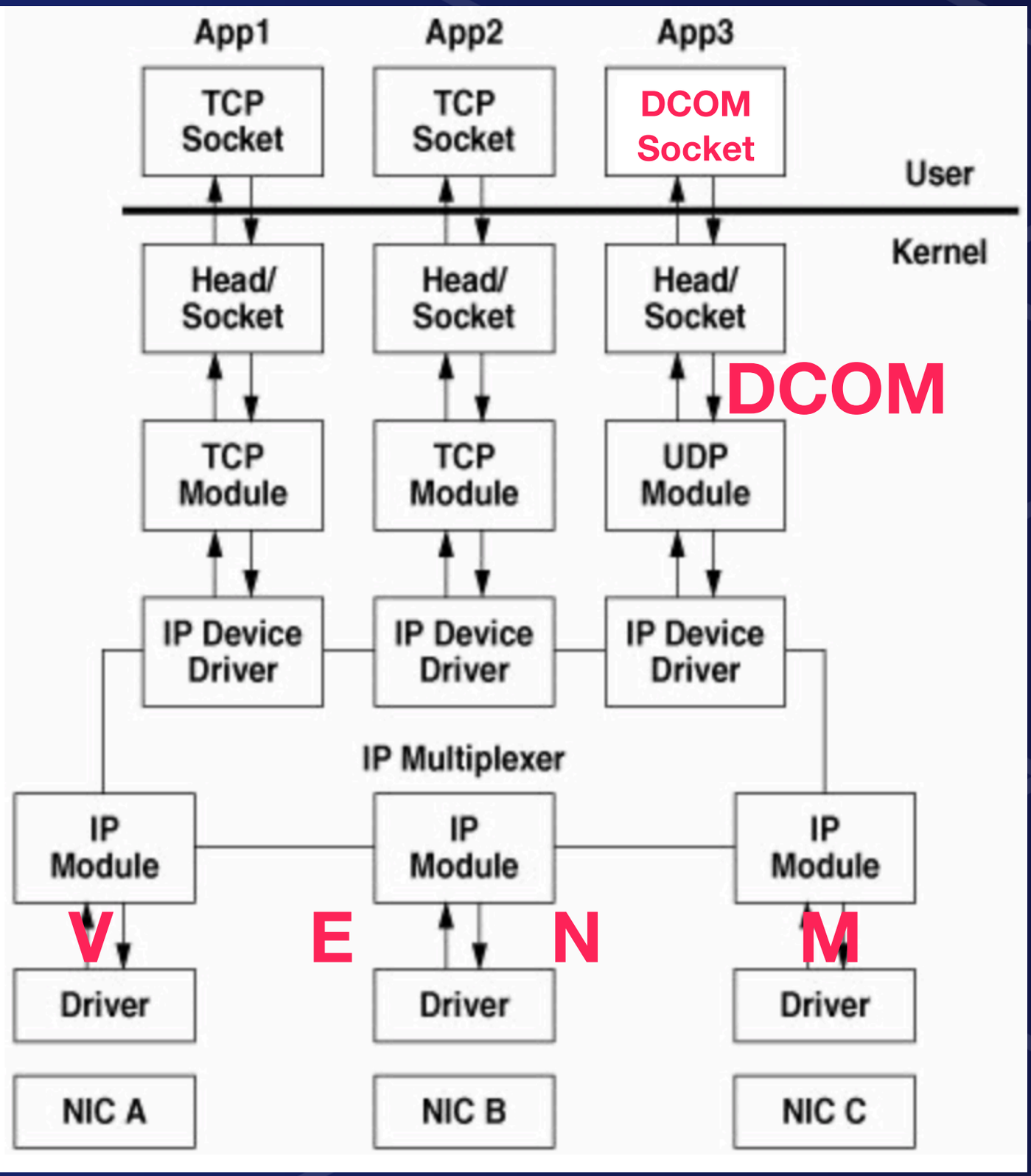

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We got extra - almost N-times performance in non-failure conditions

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ftp was the demo app

Coupling vs. Cohesion

"One goal of design is to minimize coupling between parts and to maximize cohesion within them."

Multi-Paradigm Design for C++ *James Coplien*

The Hinnant Rule

compiler implicitly declares

user declares	default constructor	destructor	copy constructor	copy assignment	move constructor	move assignment
Nothing	defaulted	defaulted	defaulted	defaulted	defaulted	defaulted
Any constructor	not declared	defaulted	defaulted	defaulted	defaulted	defaulted
default constructor	user declared	defaulted	defaulted	defaulted	defaulted	defaulted
destructor	defaulted	user declared	defaulted	defaulted	not declared	not declared
copy constructor	not declared	defaulted	user declared	defaulted	not declared	not declared
copy assignment	defaulted	defaulted	defaulted	user declared	not declared	not declared
move constructor	not declared	defaulted	deleted	deleted	user declared	not declared
move assignment	defaulted	defaulted	deleted	deleted	not declared	user declared

What's the Catch?

If this design is so great, why don't I know anything about it?

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My personal opinions and guesses...

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STREAMS is kernel only

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You must load and run your modules in the kernel

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STREAMS is kernel only

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Recommendation was no more than 6-7 modules

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Poor Linux Support

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Linux Fast-STREAMS 2006 - great throughput

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Java style object oriented - difficult to compose

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Performance

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Performance

Full implementation is hard

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Performance

Full implementation is hard

Can require custom scheduler for service routines

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Performance

Full implementation is hard

Can require custom scheduler for service routines

Less chance for compiler optimizations

What's the Catch?

If this design is so great, why don't I know anything about it?

Performance

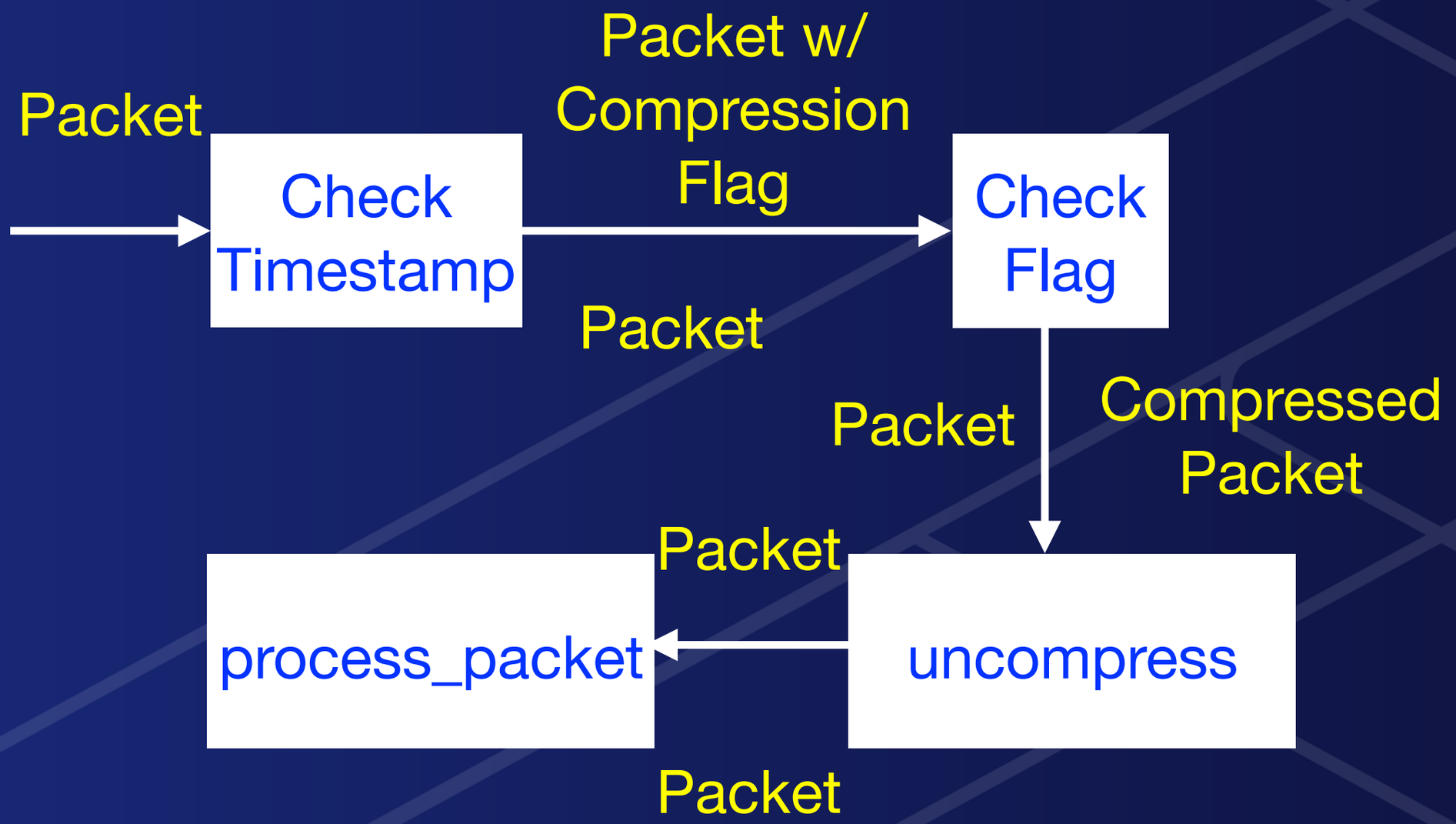
Full implementation is hard

Can require custom scheduler for service routines

Less chance for compiler optimizations

Function calls and runtime checks via opaque messages

Coupling vs. Cohesion



Ever Seen an Ugly Baby?

All parents think their baby is beautiful

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I am under no such illusion

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Difficult to use right :-(

Check Timestamp

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auto check_timestamp = [](auto & fw, Packet const & pkt)
-> decltype(
    add_tag<HasCompressionFlag>(fw, pkt),
    bool{supports_compression(pkt)},
    void())
{
  if (supports_compression(pkt)) {
    put_next(fw, add_tag<HasCompressionFlag>(fw, pkt));
  } else {
    put_next(fw, pkt);
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-> decltype(
    check_tagged<Compressed>(fw, ev),
    uncompress(event_for(fw, ev)),
    void())
{
  put_next(
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      remove_tag<Compressed>(
          fw,
          tag_as(fw, ev)(
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Process Packet

```
auto process_packet = [](auto & fw, Packet const & pkt)
{
  dependency<ExchangeFooSesson>(fw).process_packet(pkt);
};
```

Building the Stream

```
auto strm = StreamHead
     | check_timestamp
     | check_flag
     | uncompress
     | process_packet
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Can make modules directly with much more optons

Can create modules whose put takes variadic arguments

The Holy Grail?

No - but it looks like a grail, and acts like a grail,
and when I close my eyes I can hear
the sound of coconuts clapping together

Journey Before Destination

The most important words a man can say are, “I will do better.” These are not the most important words any man can say. I am a man, and they are what I needed to say. The ancient code of the Knights Radiant says “journey before destination.” Some may call it a simple platitude, but it is far more. A journey will have pain and failure. It is not only the steps forward that we must accept. It is the stumbles. The trials. The knowledge that we will fail. That we will hurt those around us. But if we stop, if we accept the person we are when we fall, the journey ends. That failure becomes our destination. To love the journey is to accept no such end. I have found, through painful experience, that the most important step a person can take is always the next one.

-BRANDON SANDERSON, *OATHBRINGER*

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Other Questions?

MAYSTREET

CppCon 2022

Using Modern C++ to Revive and Old Design

AKA: Coupling and Cohesion are Guiding Lights

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