Ensō Operating System

The Kernel

Scheduler: Round-Robin, Priority Queues, Tree Flavours
Scheduler Actors: Features, Timers, Async I/O
Streams Backends: Zero-copy, Message Passing
Linear Backends: Async I/O Disk Streams, Network Streams
Indexed Backends: Timers, Actors
Backpressured Message Bus/Buffers: Arc/Vec prealloc
Class: Low Latency, Real Time

Respect Kernels History

Richard Rashid. Mach 3. NUMA, Bus Oriented Components
Dave Cutler. Windows NT. True Async I/O on IoCompletionPort
BeOS. Travis Geiselbrecht. SMP Scaling of OS services
Microkernels: RT, Tiny codebases eCos/TRON, QNX, VxWorks
Unikernels: Erlang, Mirage, HaLVM

FOUNDATION

Stream/List duality

```
pub enum List<Message> {
                Nil,
                Cons(Message, std::marker::PhantomData<List<Message>>) }

pub struct Stream<Message> {
        head: Message,
          tail: Box<Stream<Message>> }

  pub trait Stream<Message> {
            fn head(&mut self) -> Message;
            fn tail(&mut self) -> Stream<Message>; }
```

FUTURES

Zero-copy and Message Passing

```
pub trait Future<Message,Error> {
        fn poll(&mut self) -> Result<Message,Error>;
        fn tail(&mut self) -> Future<Message,Error>; }

pub trait Process<Protocol, State, Error> {
        fn state(&mut self) -> State;
        fn send(&mut self, Protocol) -> Result<State, Error>; }

pub trait Discipline<Stream<Message>> {
        fn select(&mut self, u64) -> Stream<Message>; }
```

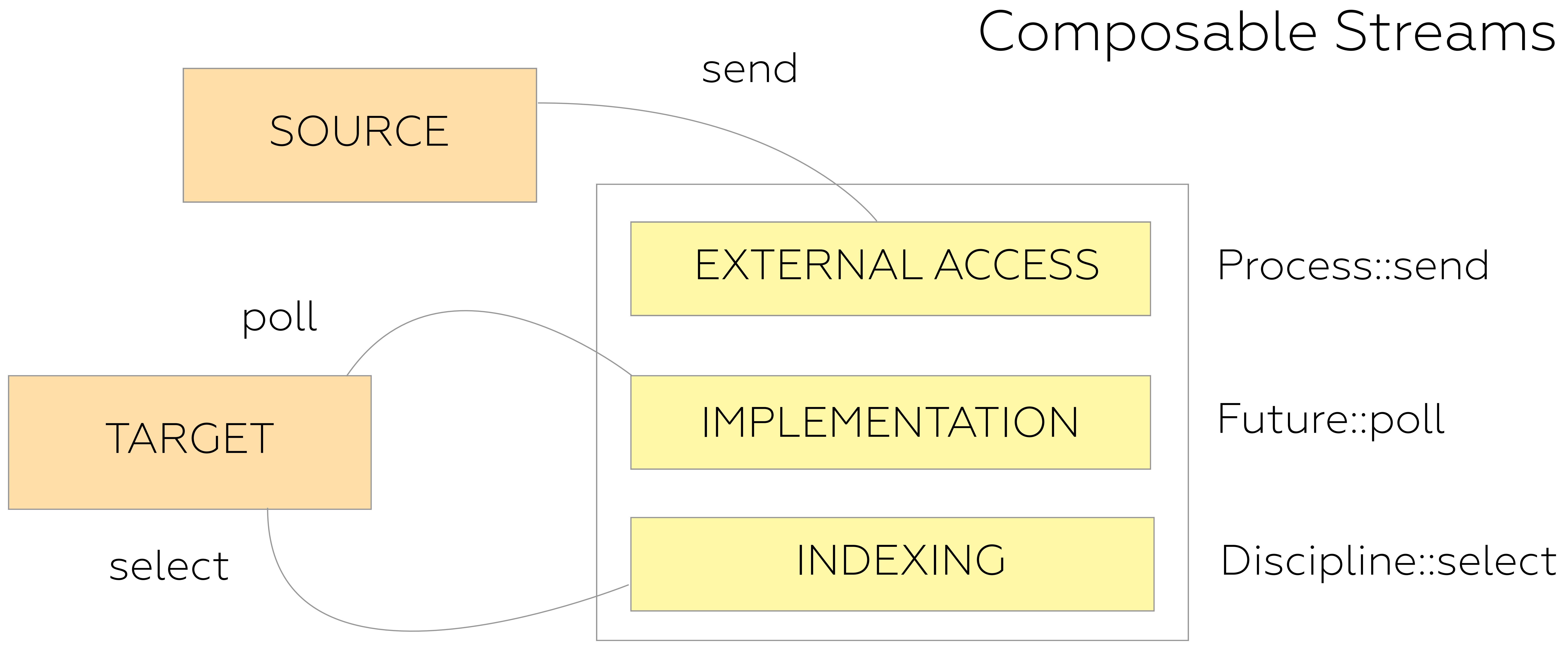
ORDERS

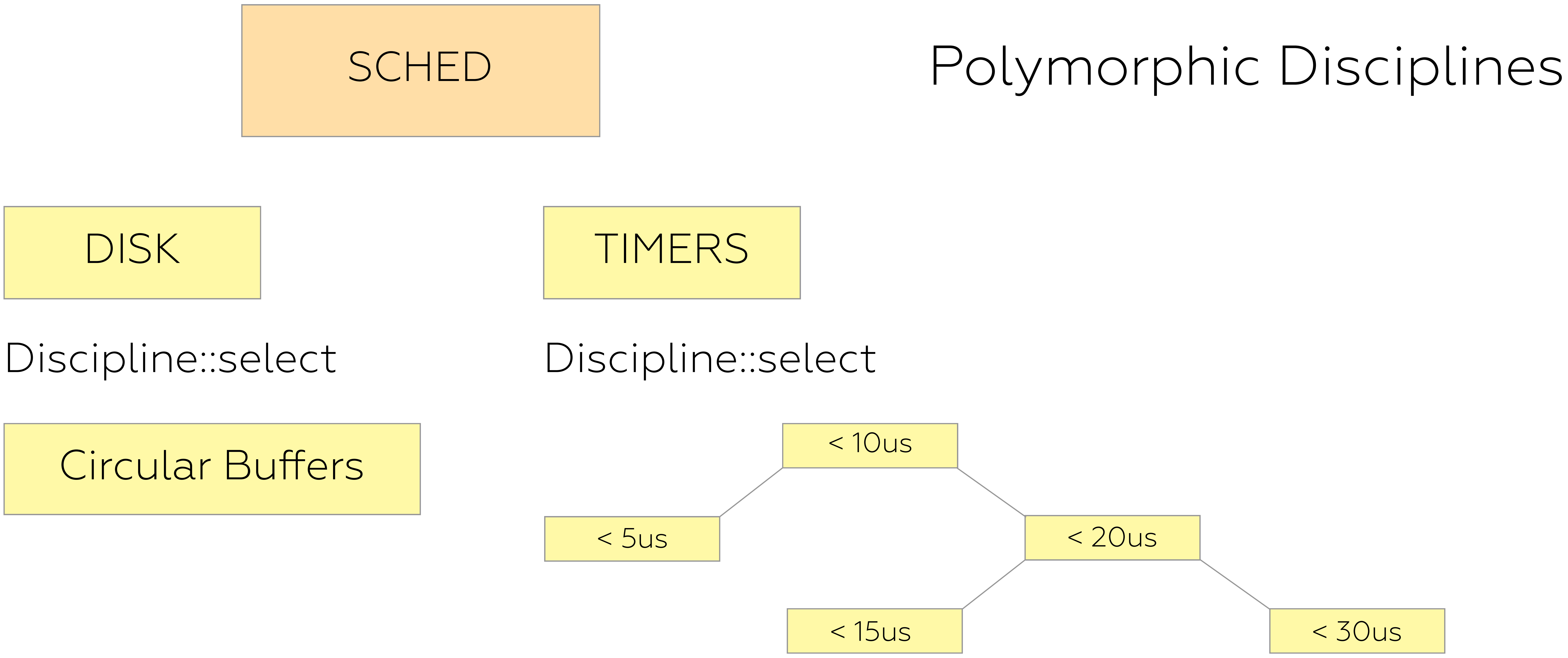
Order Processing Protocol

```
pub struct OrderState {
        state: OrderStatus,
           id: ID,
        price: Price,
         size: Size,
         side: Side, }
```

```
pub enum OrderProtocol {
        Request, Execute, Reject,
        UnsolicitedCancel,
        Cancel,
        Ack, Replace, }
```

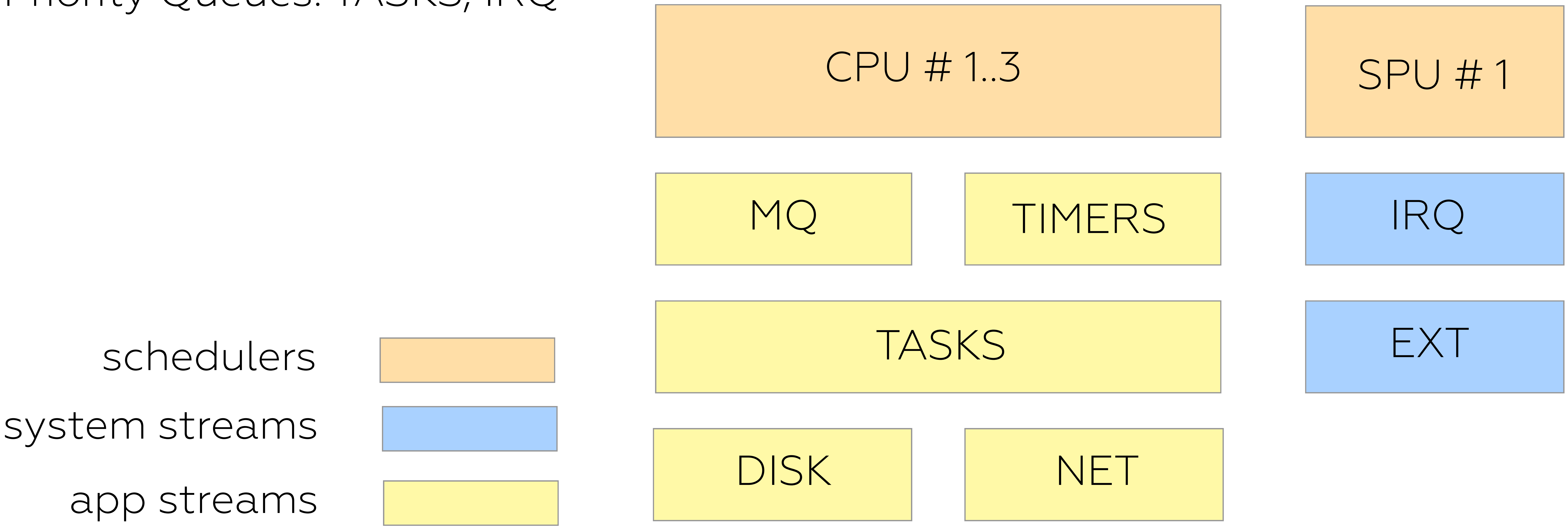
```
type OrderProcess = Process<OrderProtocol, OrderState, Error>;
```


Composable Streams
send
SOURCE
EXTERNAL ACCESS
Process::send
poll
TARGET
IMPLEMENTATION
Future::poll
select
INDEXING
Discipline::select


Polymorphic Disciplines
SCHED
DISK
TIMERS
Discipline::select
Discipline::select
Circular Buffers
< 10us
< 5us
< 20us
< 15us
< 30us

Node Components

Linear: MQ, EXT, DISK, NET
Trees: TIMERS
Priority Queues: TASKS, IRQ



REACTOR

Discipline::select

TASKS

Core Context

TOKIO

REVENT

NANOMSG

RX

Single Task Tree per Core

Scheduler::select

Reactor Requested Features

1. Reactor Core Context
2. Task Context
3. Scheduleable Entities
4. Task List
5. Task Selection by Priority
6. API: spawn/select/poll
7. Inspirational Libraries: Rx, Nanomsg, Tokio

MQ

Vec, VecDeque, Link, Turbine, Pipes

Queue Types

(rx , tx)

CHANNEL

Discipline::select

SPSC/LINK

MPSC/SUB

SPMC/PUB

Non-schedulable Array Store

Queues Requested Features

1. Three Basic Drivers: SPSC, MPSC, SPSC
2. Different Backends: Vec, VecDeque, Link, Turbine, Pipes
3. Queue Properties
4. Queue with Priorities
5. API: create/pub/sub/link
6. Inspirational Libraries: Turbine, Rust Queues, Pipes

TIMERS

Discipline::select

TIMER

(interval , task_id)

TOKIO

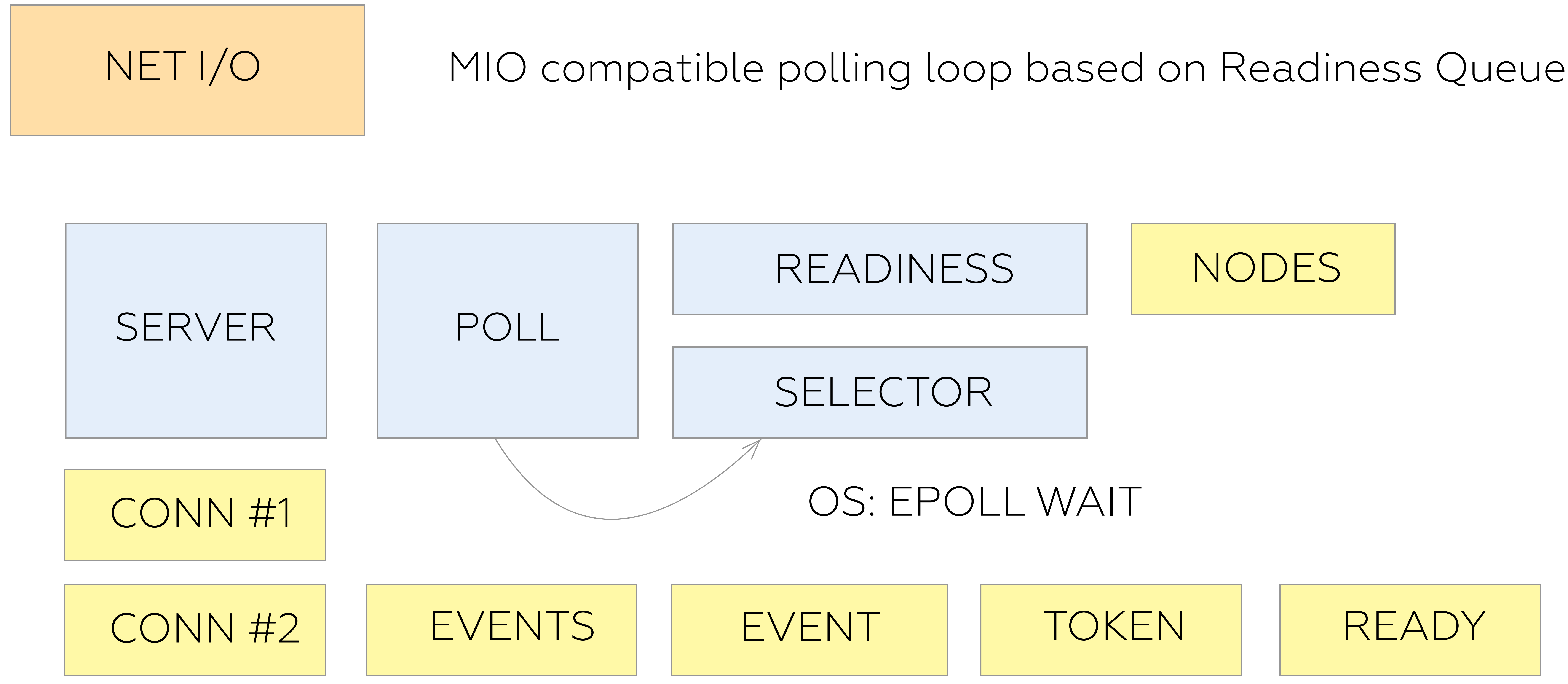
Dedicated Core or Interrupt Queue

RX/RUST

Scheduler::select

Timers Requested Features

1. Timers Core Context
2. Timer Types: Oneshot Scalable Timers, Fixed List of Interval Timers
3. API: create/select/poll
4. Inspirational Libraries: Tokio, Rx


NET I/O
MIO compatible polling loop based on Readiness Queue
SERVER
POLL
READINESS
NODES
SELECTOR
OS: EPOLL WAIT
CONN #1
CONN #2
EVENTS
EVENT
TOKEN
READY

Network I/O Features

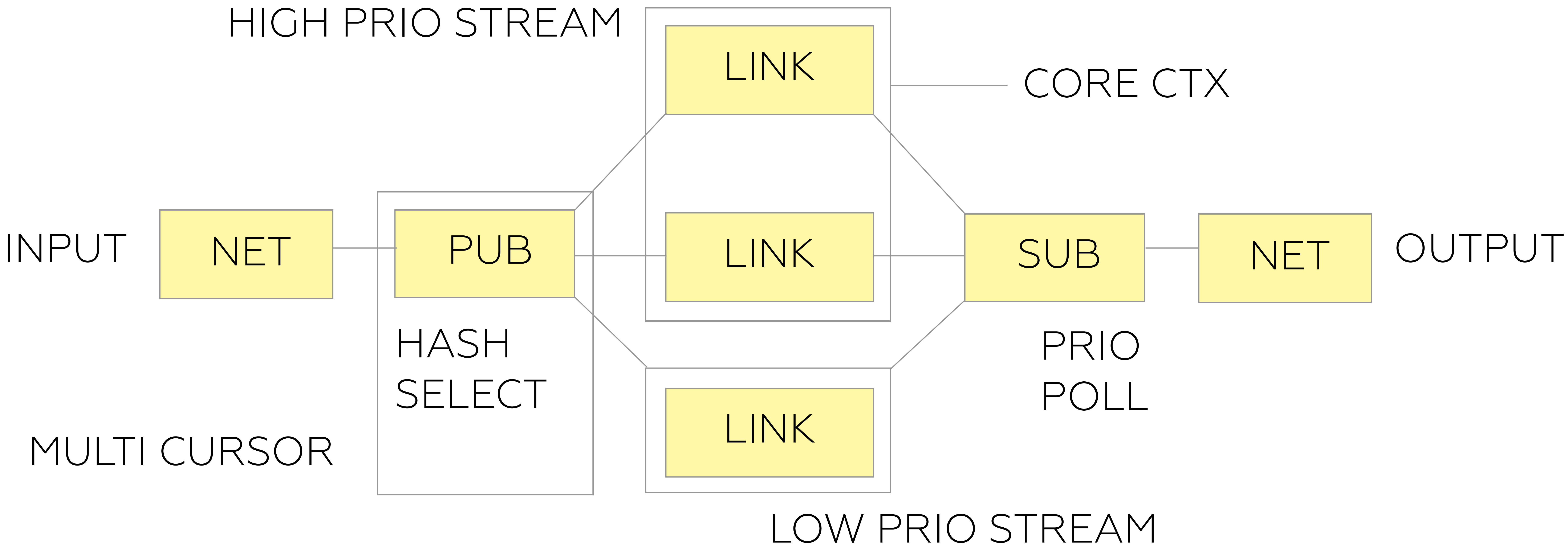
```
$ . ../cmplxt.sh

struct   32
trait     2
impl     85
```

1. MIO compatible API
2. Evented Polling on Linux, BSD, XSOCK
3. Connection State
4. API: create/select/poll
5. Close to FFI API
6. Client and Server Samples

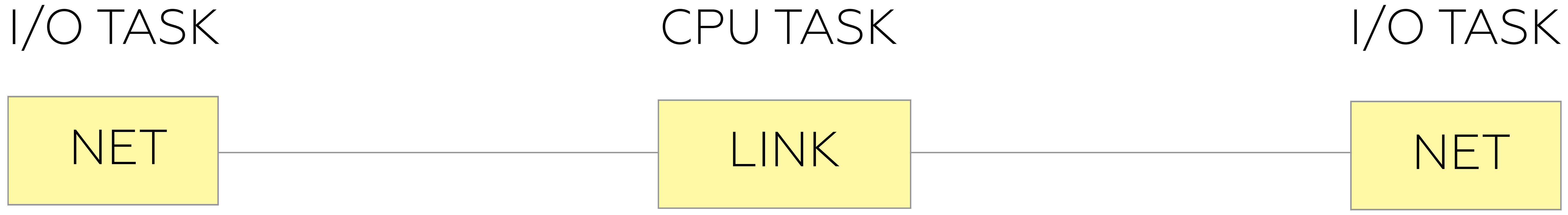
LOAD BALANCING CASE

Load Balancing
of Priority Streams per Core Buckets



FAST DELIVERY CASE

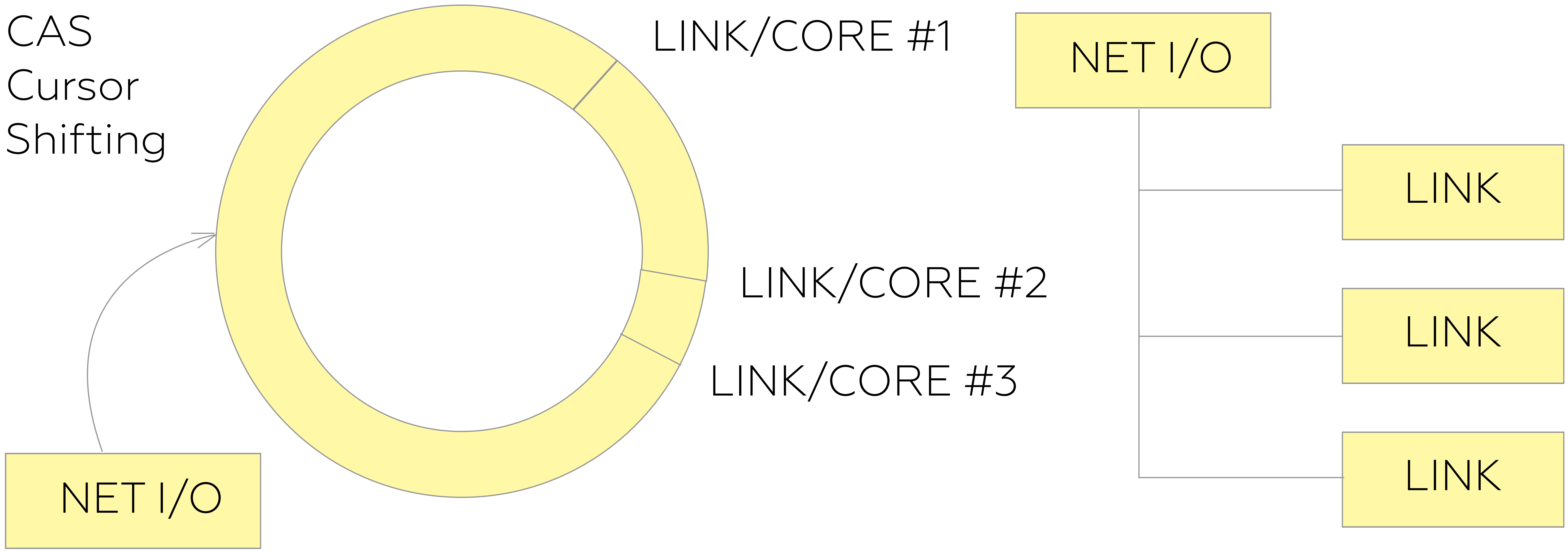
Single Threaded Task Configuration
to be compared as reference



You can use inplace message modifying and reduce copies to unpack and pack.

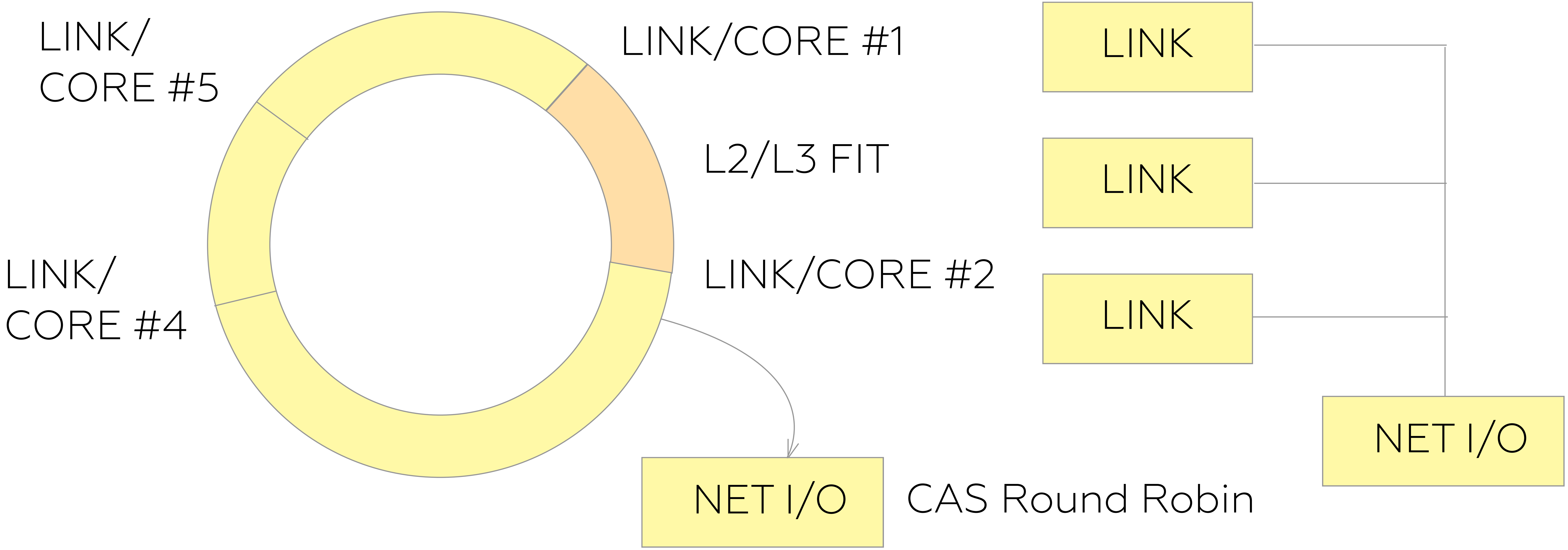
PUBLISHER CASE

PUB Implementation for Zero-Copy
Multiple Consumer Publishing (SPMC)



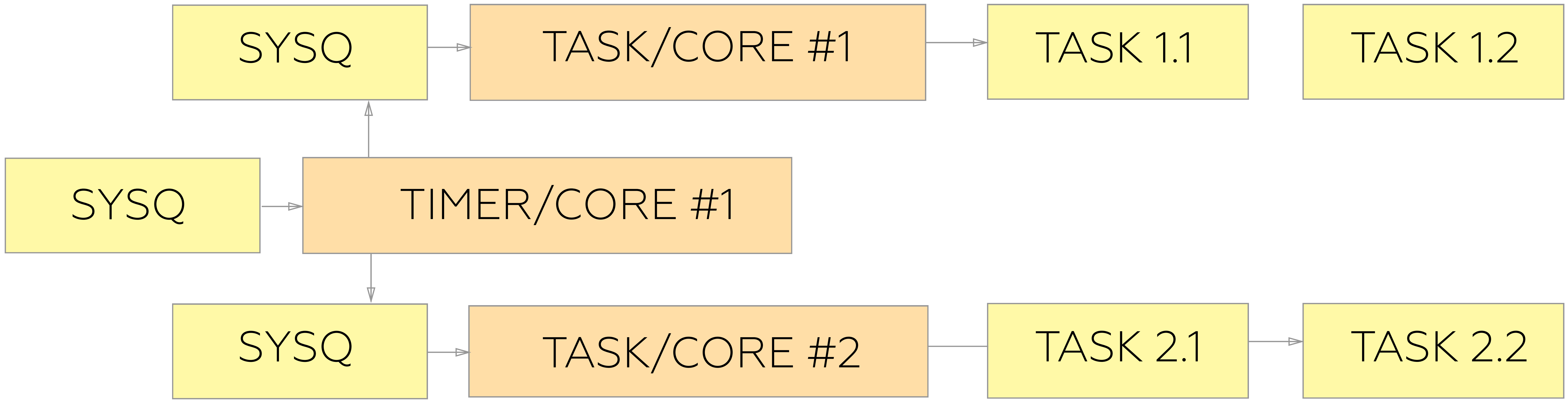
SUBSCRIBER CASE

Multicursor Implementation of SUB
for InterCore Queue Migrations and Cache Locality



INTERCORE QUEUES

Scheduler Reactors can communicate throught InterCore transport when needed.



Network Polling also could be seen as InterCore single sourced Queue for Task Delivery.