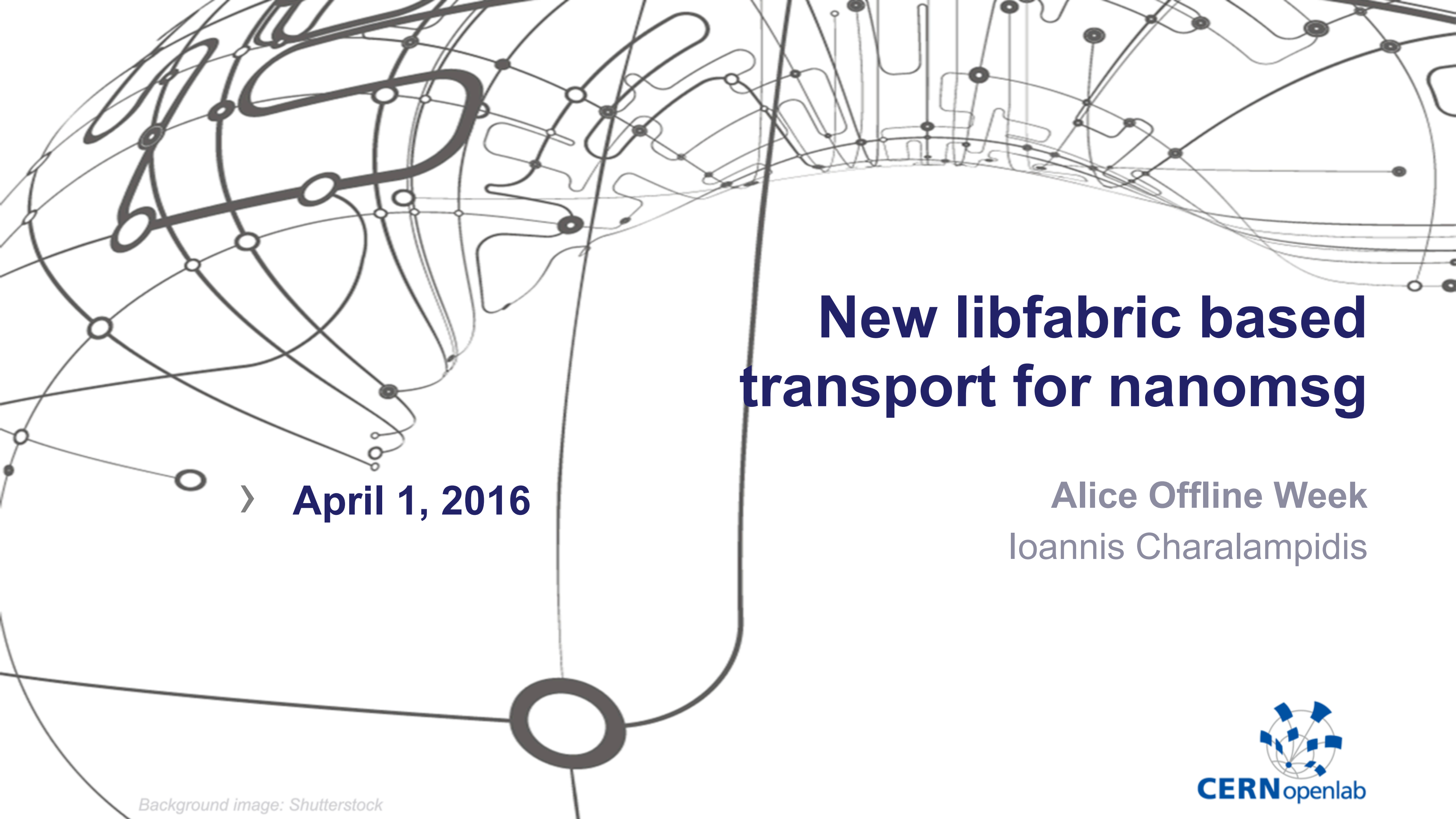

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New libfabric based transport for nanomsg

› **April 1, 2016**

Alice Offline Week

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CERNopenlab

A bit of Background

- **Openlab collaboration with CISCO**
  - Interface CISCO’s user-space NICs (`usNIC`) to ALICE experimental software
  - Benchmark performance
  - Decide on further use-cases
- **An interesting by-product**
  - A new transport for the `nanomsg` library
  - https://github.com/wavesoft/nanomsg-transport-ofi/

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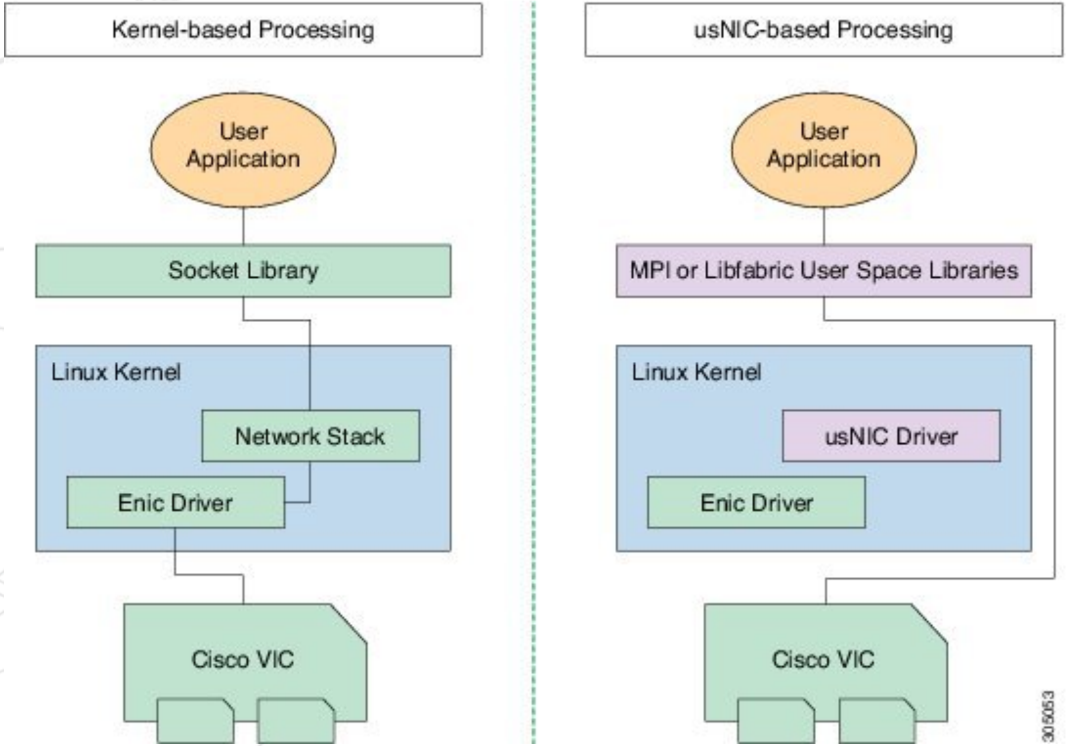
“User-Space” NIC



Bypass the Linux Kernel and communicate directly with the NIC from User Space

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ALICE Software & usNIC

- **Requirements**
  - It must interface with current ALICE software without any modification in them
- **Extend FairMQ**
  - It's a lightweight wrapper around `ØMQ` / `nanomsg`
  - We have to extend `nanomsg` or `ØMQ`
  - We decided to go with **`nanomsg`**, because of cleaner and easily extensible API

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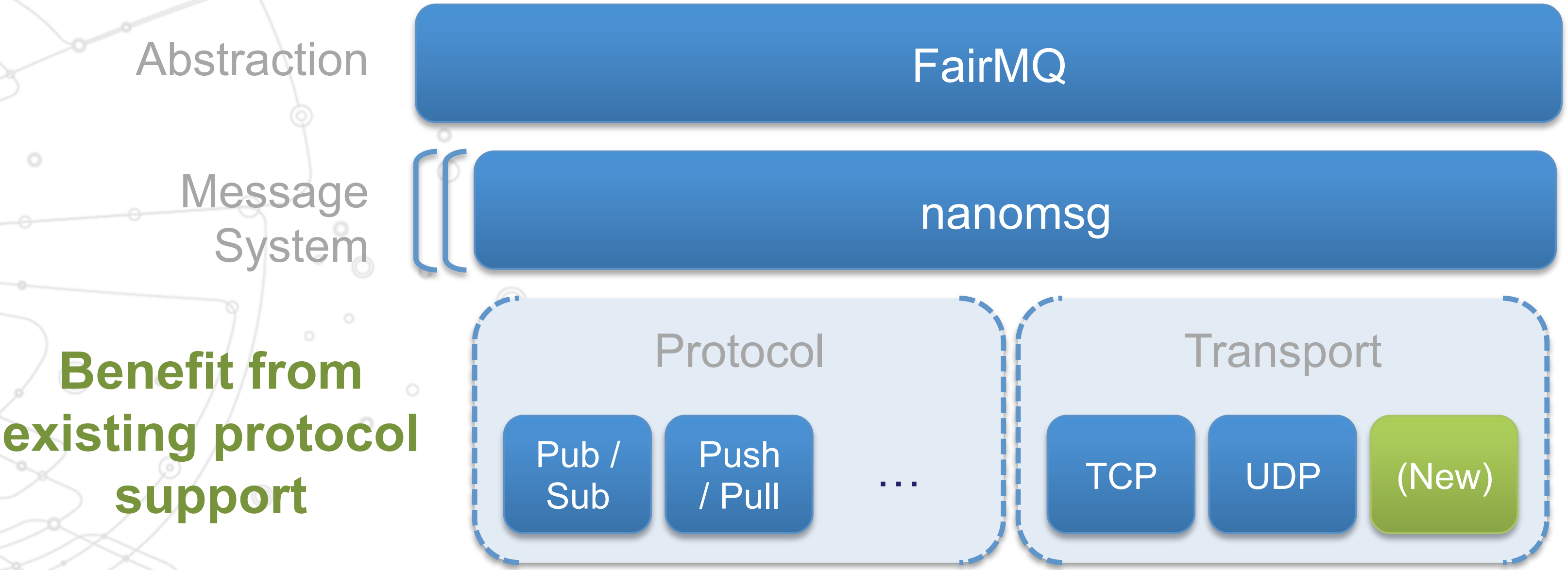
Extending `nanomsg`



Benefit from existing protocol support

Focus on the transport

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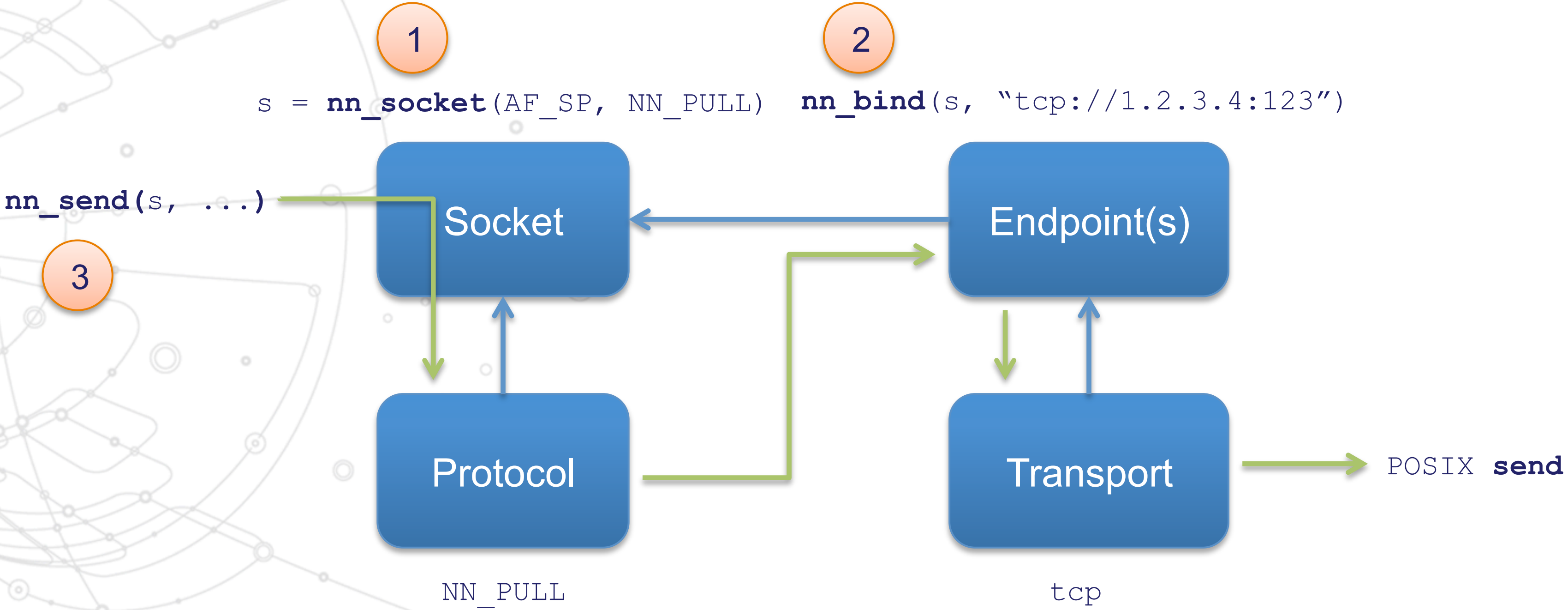
Components of nanomsg



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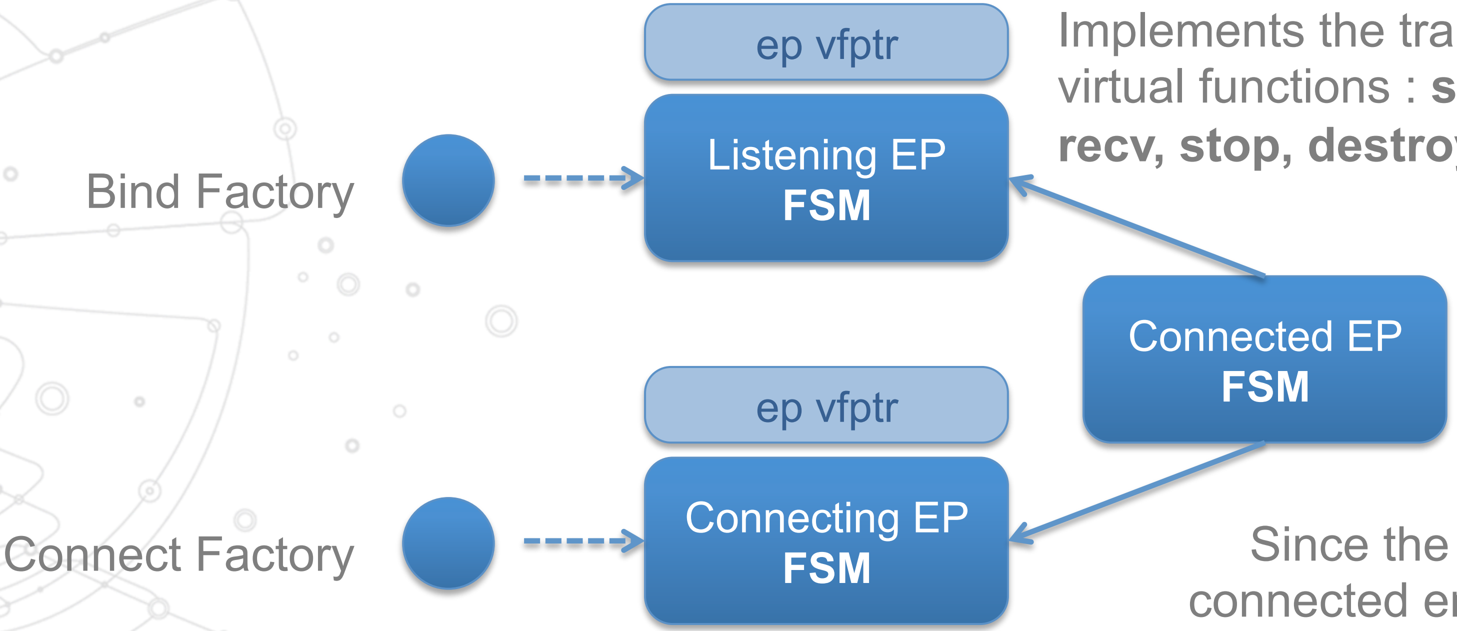
Transport in `nanomsg`



Implements the transport virtual functions : **send, recv, stop, destroy**

Since the logic of a connected endpoint is the same, it's isolated in a separate FSM

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Interfacing to usNIC

- **Difficulties**
  - The core of ØMQ or NanoMsg is designed around the UNIX sockets
  - usNIC API is closer to MPI or RDMA
- **We are using `libfabric`**
  - It is somewhere in the middle

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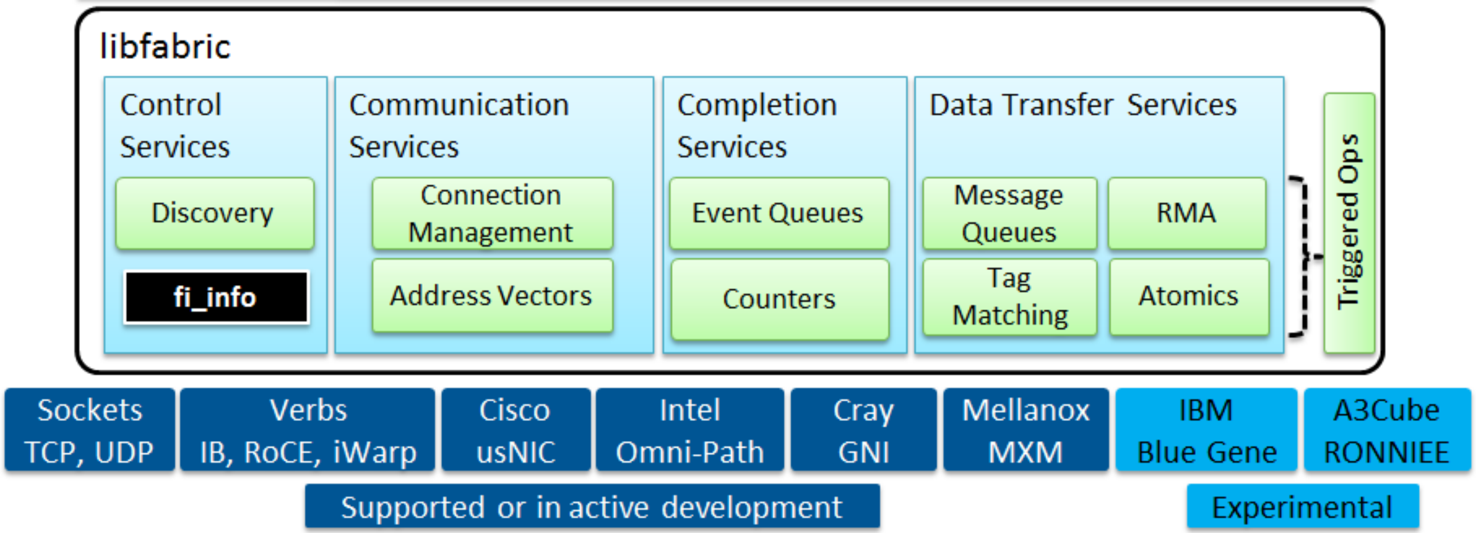
OpenFabrics Interfaces (OFI)

Unified **`libfabric`** API



libfabric

Control Services

Discovery

fi_info

Communication Services

Connection Management

Address Vectors

Completion Services

Event Queues

Counters

Data Transfer Services

Message Queues

RMA

Tag Matching

Atomics

Triggered Ops

Sockets TCP, UDP

Verbs IB, RoCE, iWarp

Cisco usNIC

Intel Omni-Path

Cray GNI

Mellanox MXM

IBM Blue Gene

A3Cube RONNIEE

Supported or in active development

Experimental

Different Low-Lattency, High-Performance Fabric Hardware

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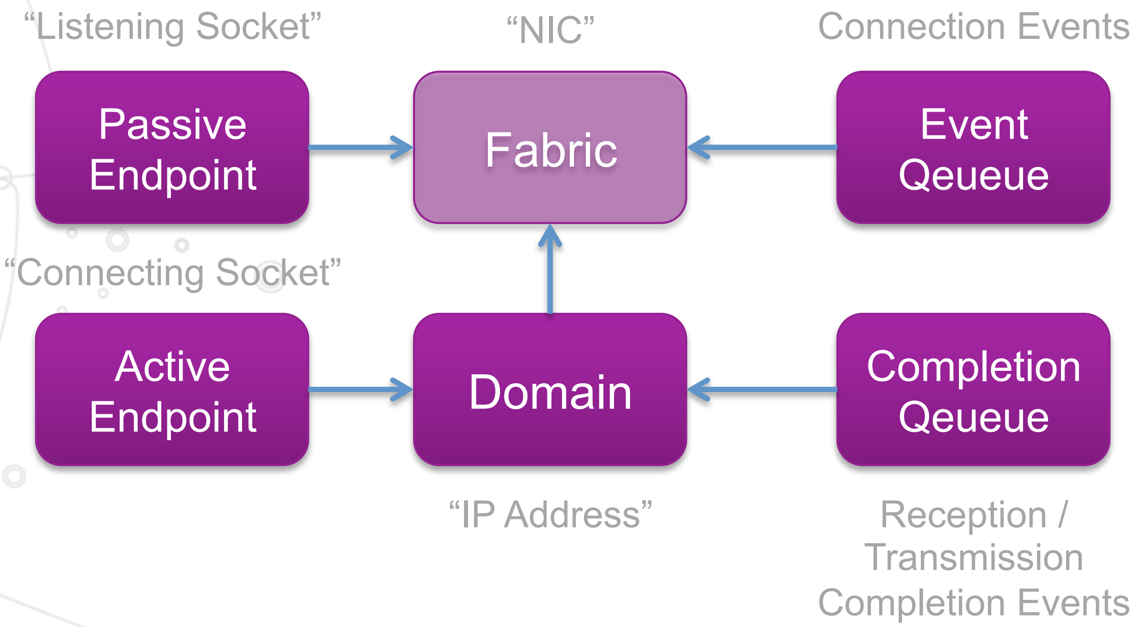
libfabric Terminology



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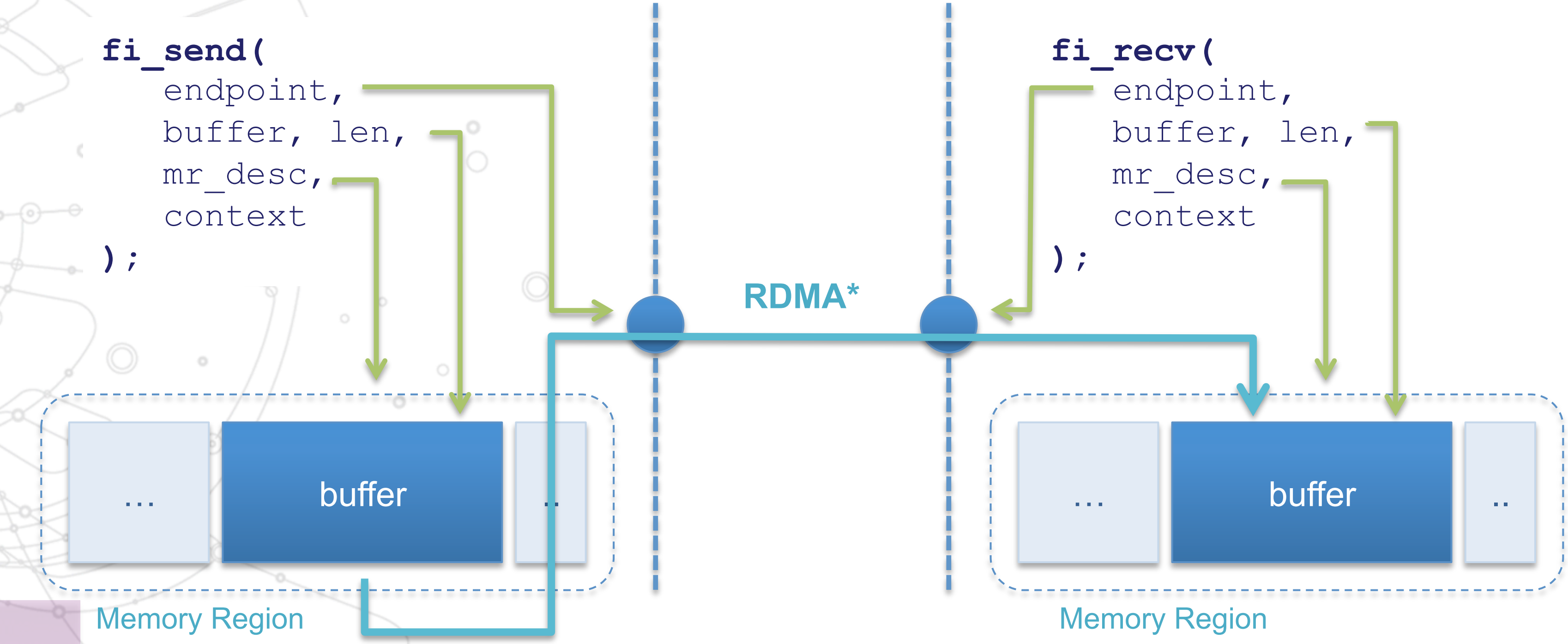
`libfabric` Features

- **Active Endpoint Types**
  - `FI_DGRAM` – Unreliable Datagrams (ex. UDP)
  - `FI_RDM` – Reliable Datagrams (ex. RDMA)
  - `FI_MSG` – Connection-aware message passing (ex. TCP)
- **High-level API is close to socket API**
  - The provider implements fragmentation and flow control
  - Simple functions : `fi_send(), fi_recv()`
  - It uses RDMA behind the scenes!

libfabric API



```
fi_send(
    endpoint,
    buffer, len,
    mr_desc,
    context
);
```

```
fi_recv(
    endpoint,
    buffer, len,
    mr_desc,
    context
);
```

RDMA*

…

buffer

..

Memory Region

…

buffer

..

Memory Region

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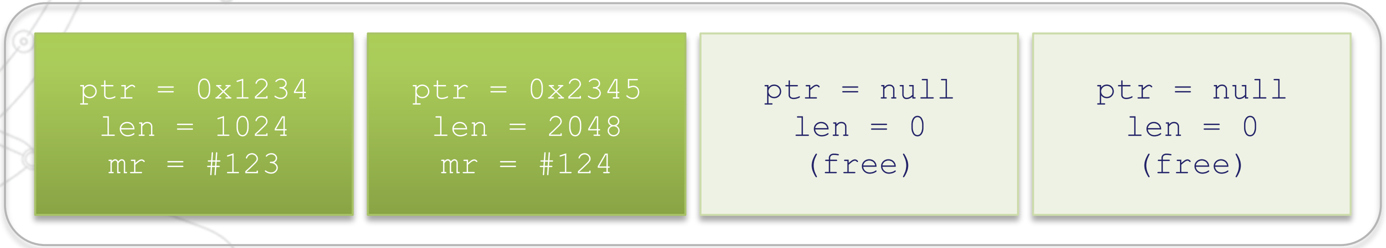
Memory Registration

- **Register outgoing messages on-the-fly**
  - OFI transport has re-usable memory “banks”
  - If the pointer being sent belongs to a registered region, the MR description from that bank will be used
  - Otherwise the oldest bank will be de-registered and populated with the new pointer information



ptr = 0x1234
len = 1024
mr = #123
	ptr = 0x2345
	len = 2048
	mr = #124
		ptr = null
		len = 0
		(free)
			ptr = null
			len = 0
			(free)

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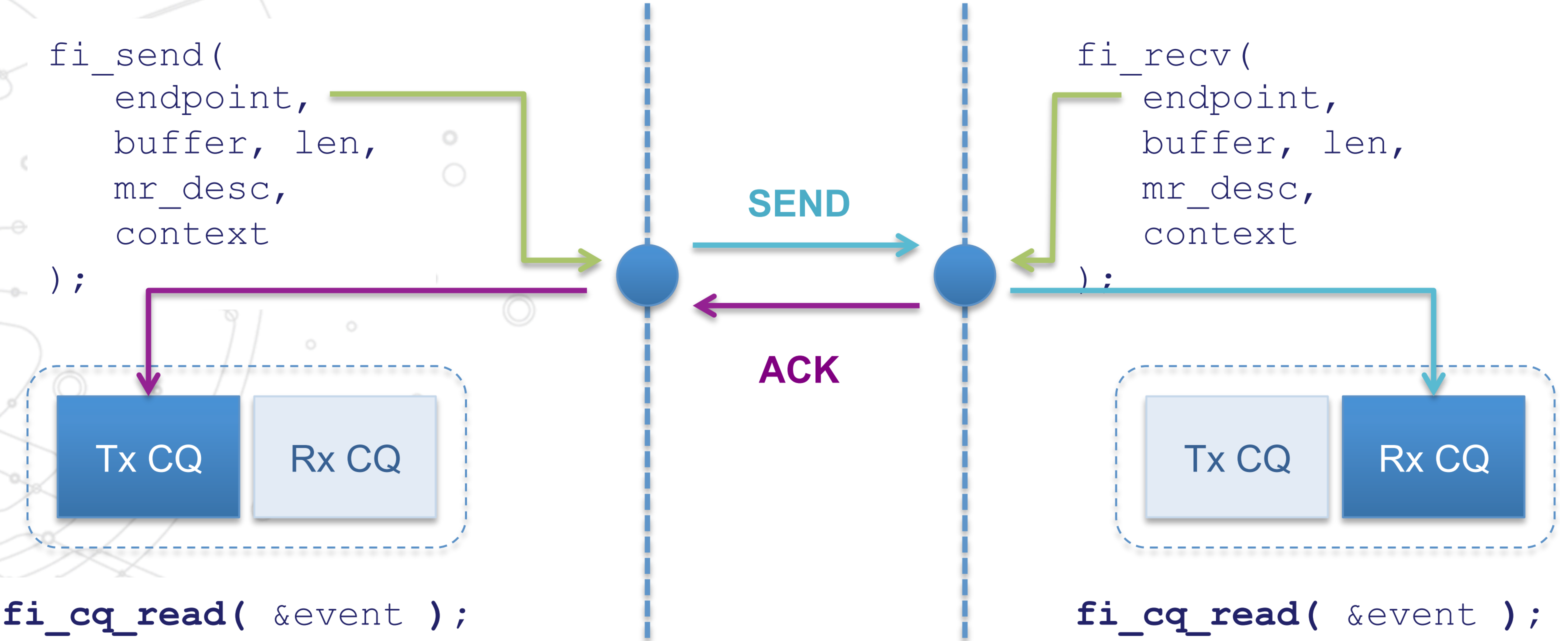
libfabric Events



```
fi_send(
    endpoint,
    buffer, len,
    mr_desc,
    context
);
```

```
fi_recv(
    endpoint,
    buffer, len,
    mr_desc,
    context
);
```

```
fi_cq_read( &event );
```

```
fi_cq_read( &event );
```

* libfabric has custom event polling functions

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Receiving Events

- **`libfabric` API has custom polling functions**
  - We cannot re-use the existing FD-based solutions *
- **OFI Transport polls the CQs and EQs**
  - A dedicated thread polls all the currently active CQs/EQs and it forwards the events to the appropriate endpoint FSMs
  - Where supported, it uses *wait sets* to synchronously wait for an event from any source, otherwise it spins

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Receiving Events

- **** NOTE: The libfabric specs DO support FDs***
  - *It's possible to create an EQ or CQ with an underlying 'waitable' object, such as a mutex or a file descriptor*
  - *However it's not (yet) supported by all providers*

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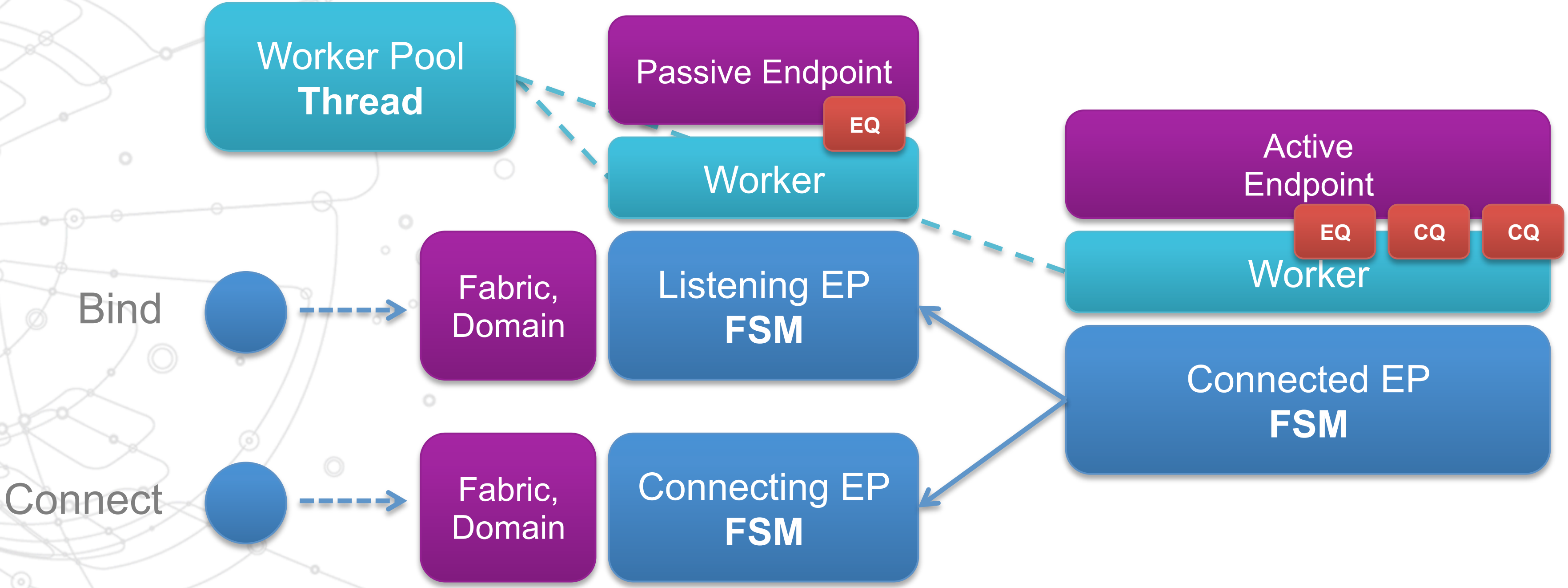
The OFI Transport



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The OFI Transport

- **The ‘ofi’ transport is selected with the nanomsg uri:**
  - `ofi://ip:port[@fabric[:provider]]`
  - The appropriate fabric is selected by it’s IP address and/or the fabric specifications provided
- **Seamless transition to other providers**
  - The transport is completely agnostic to the provider. The same code works the same with infiniband, omnipath, usnic etc.

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Zero-Copy in `nanomsg`

- **Buffers in `nanomsg` are organized in chunks**
  - Each chunk has a reference counter
  - Instead of copying, it increments the reference number
- **When data from a raw pointer are to be sent, they are copied in a new chunk**
  - In order to avoid this, the `nn_allocmsg` function should be called to allocate a new chunk in advance
  - Till now (v0.8-beta) it’s not possible to allocate a chunk from existing data

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Additions to `nanomsg`

- **1. Chainable chunk destructors**
  - To allow transports to track when a chunk is free’d in order to invalidate the memory registration.
- **2. Create `nn_msg` from user pointer**
  - Instead of letting nanomsg allocate the message body, the the function `nn_allocmsg_ptr` enables creation of a zero-copy message from existing data
- Pull request submitted :
  - https://github.com/nanomsg/nanomsg/pull/612

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Benchmarks

Test set-up

- Intel Xeon E5-2690
  - 2.9 GHz
  - 8 core (16 threads)
  - L2 8x256 KB
  - L3 or LLC (8x2.5MB)
- InfiniBand FDRx4 (56 Gb/s)
  - Mellanox MT27500 (ConntctX-3)

- CentOS 7.2.1511
  - 3.10.0-327.4.5.el7.x86_64

- nanomsg-transport-ofi 1.0.0
  - Beta version

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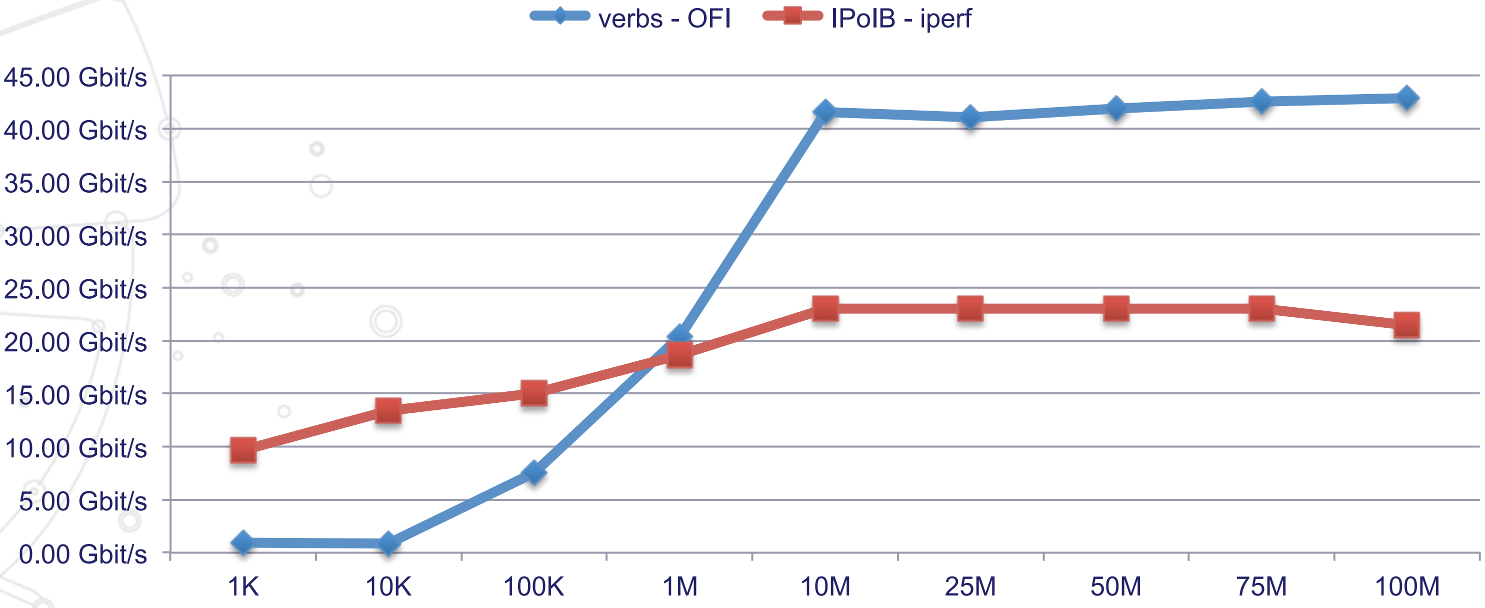
Benchmarks



***Warning!** Preliminary results with early beta version of the transport.*
More benchmarks are currently undergoing.

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Conclusions

- The nanomsg OFI transport enables **socket-like** interface to high performance RDMA fabrics, such as Infiniband, Omni-Path, usNIC etc.
- Even from the early development versions the **performance** measurements looks promising
- There is still lots of room for **improvement**
  - Better memory registration, stability issues, etc.

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