OBJECTIVE (TODAY)

- Describe what we’re trying to accomplish, and its rationale
- Describe the approach being taken
- Ask for your feedback/direction check - Is this an acceptable direction that merits further development?

OPENFABRICS ALLIANCE

12th ANNUAL WORKSHOP 2016

Pathfinding a Kernel Storage Fabric Mid-layer

Scott Atchley, Stan Smith, Paul Grun

April 2016

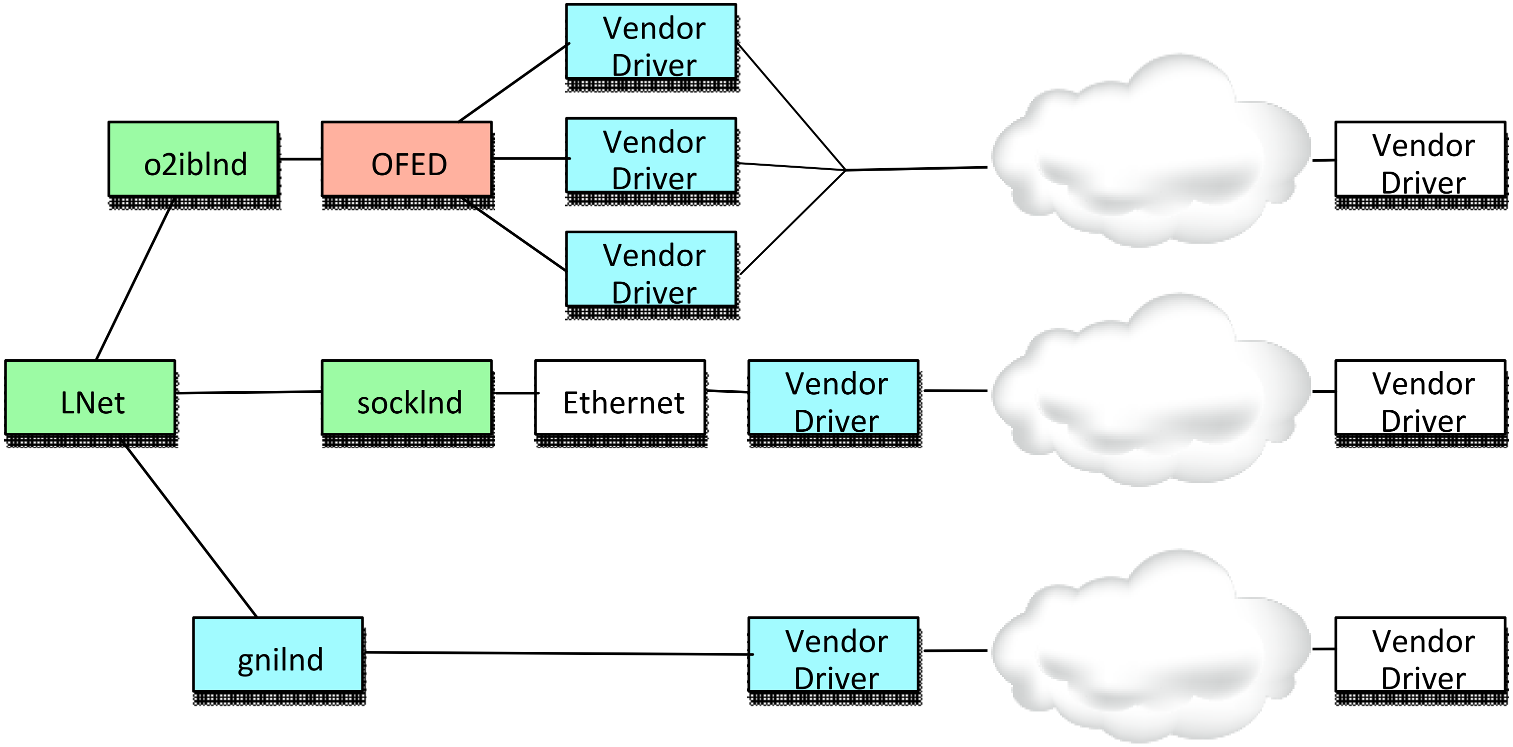
Kernel Fabric Observations

- **Kernel fabric clients (ULPs) require a fabric device specific bottom edge in order to interface with kernel fabric devices**

- **Each ULP is forced to define a fabric transport abstraction layer and then meld the fabric device specific behavior into their fabric transport abstraction; often 8+ months of development work**
  Case in point:
  - LNET is the fabric transport abstraction
  - A Lustre Network Driver (LND) is required for each supported fabric:
    LNDs for IB/iWARP, Cray GNI, ksockets, non-QP based devices…

- **NVMe over Fabrics (NVMe/F), NFS/RDMA, iSER/SRP have the same ULP-to-fabric device I/F issues as Lustre in order to support new interconnects**

Current Lustre LND Architecture



🟩 Supported by Lustre Community
🟦 Supported by HW Vendors
🟥 Supported by OpenFabrics Community

Pathfinding Conclusions

- **Reduction in storage ULP fabric device I/F development time for new fabric devices is desirable**

- **Multiple storage ULPs could utilize a common fabric mid-layer**

- **A storage fabric mid-layer would be RMA device agnostic in order to support current and future RMA devices**
  - Not all fabric devices are Queue-Pair based
  - Support diverse fabrics w/o requiring emulation of an existing fabric (i.e not wire compatible)

- **Fabric mid-layer would present a consumer-oriented message transfer abstraction**
  - Minimize device specific special cases above message transfer layer

- **Support emerging fabric use cases – NVMe for remote storage (NVMe/F)**
  - NVMe is PCIe slot and device [0…255] limited
  - NVMe/F gains access to 'more' NVMe resources at 'near local' speeds
  - Sharing NVMe data over the fabric
  - Data replication / Mirroring using RMA (multicast+) especially for NVDIMMs
  - All RMA writes must reach a durability point before signaling completion

Hold on, it’s not a QP device…

Fabric Mid-layer Objectives

- **Kernel storage ULP I/F requirements drive fabric mid-layer messaging API design**
  - File systems, object I/O, block storage, persistent memory (emerging)
- **Fabric agnostic**
  - Support for new fabrics should not require emulating an existing one
    - Device drivers are typically based on a specific fabric technology
- **Support for emerging fabrics…**
  - Allow for innovation from new fabrics as they emerge
- **While still supporting existing networks**
  - Must be able to support existing network technologies

kfabric Mid-layer Proposal

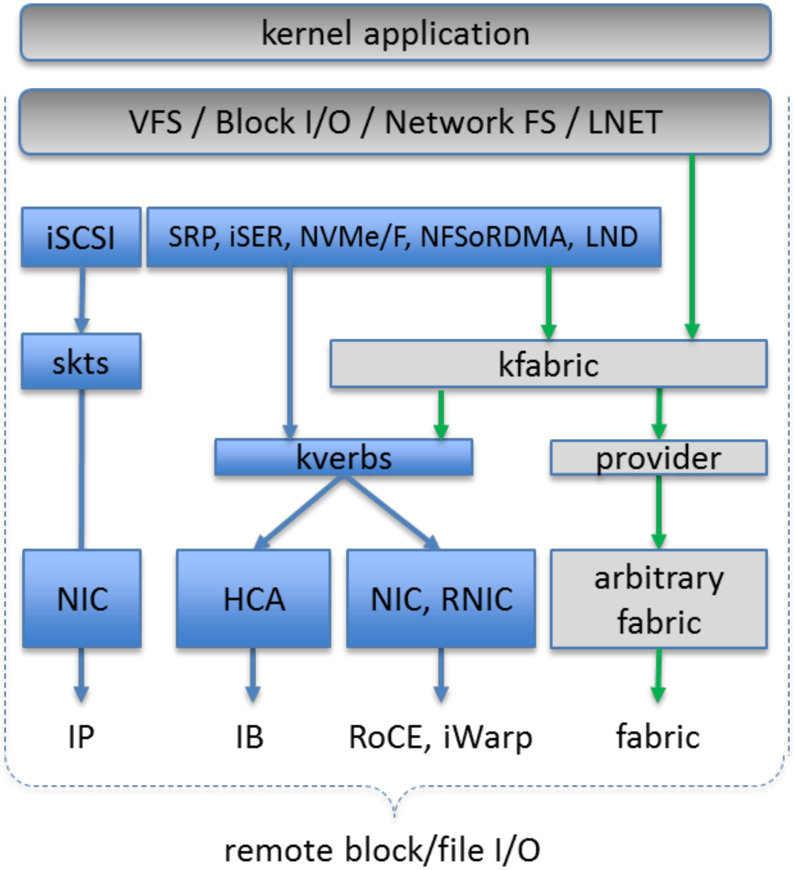
- **kfabric: an abstract, kernel mode API for storage**
  - API is expressed in terms of message passing operations, not fabric device protocols (e.g. 'write message' vs 'post send request')
  - Fabric provider does address resolution in consumer-provider agreed upon address format

- **Emerging NVMe/F technology can benefit from a transport neutral, RMA-enabled fabric mid-layer**

- **kfabric designed in 'spirit' around libfabric concepts**
  - RMA device agnostic (consider SCSI mid-layer common code design)
  - Reduce/Simplify ULP fabric device specific I/F code
    - Device specifics contained in the provider module, not in ULP
    - NVMe/F and Lustre LND fabric I/F implementations reap benefits (code reduction/simplification) from kfabric mid-layer

Demand exists for an abstract, fabric mid-layer API based on RMA

kfabric Mid-layer Stack



kernel application

VFS / Block I/O / Network FS / LNET

iSCSI

SRP, iSER, NVMe/F, NFSoRDMA, LND

skts

kfabric

kverbs

provider

NIC

HCA

NIC, RNIC

arbitrary fabric

IP

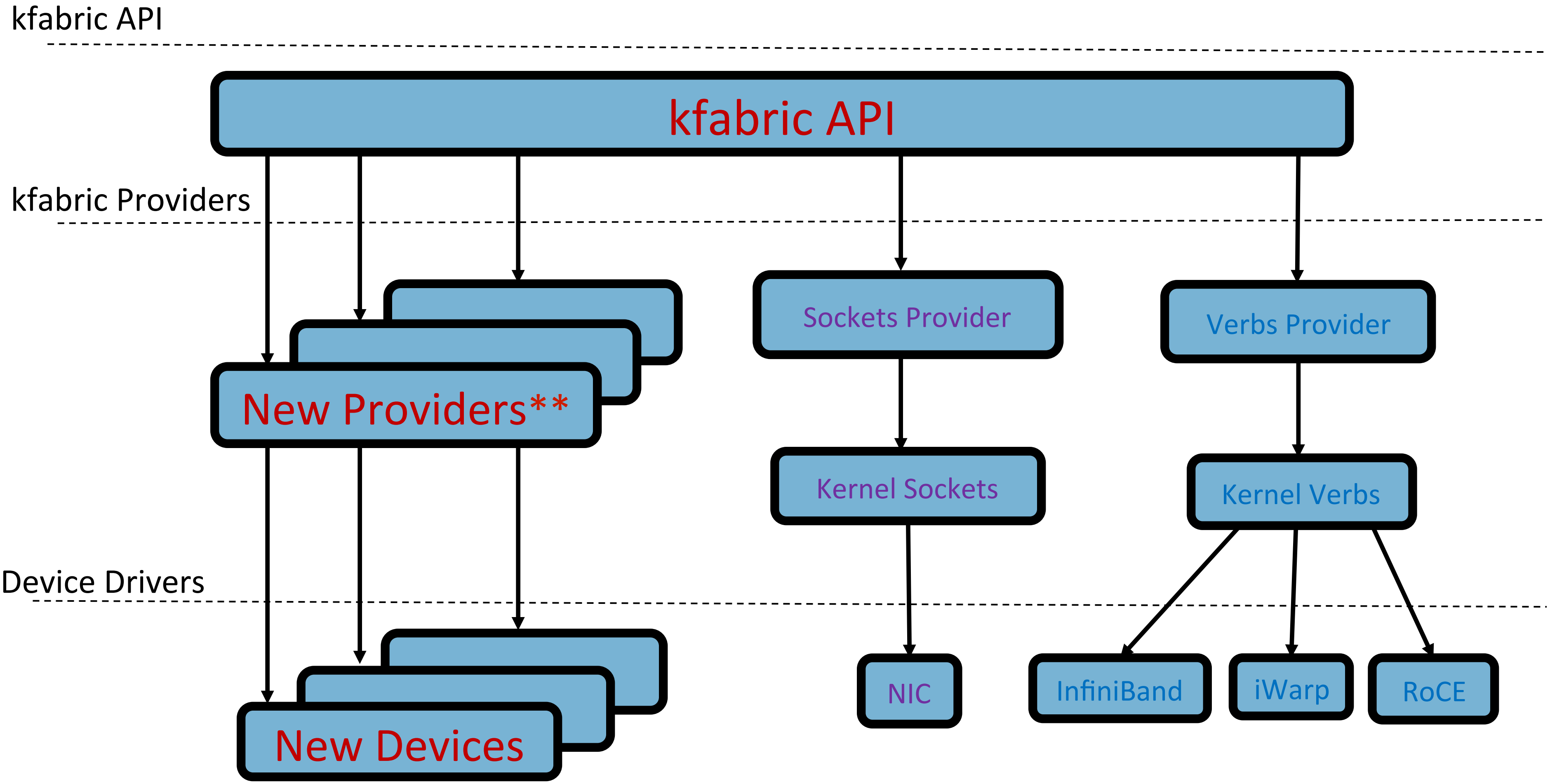
IB

RoCE, iWarp

fabric

remote block/file I/O

kfabric Mid-layer Framework



Red = new kernel components, ** = e.g. NVM

kfabric API

kfabric consumer API module (exports)

- fi_getinfo() fi_fabric() fi_domain() fi_endpoint() fi_cq_open() fi_ep_bind()
- fi_listen() fi_accept() fi_connect() fi_send() fi_recv() fi_read() fi_write()
- fi_mr_reg/v() fi_cq_read() fi_cq_sread() fi_eq_read() fi_eq_sread() fi_close() …

kfabric API

kfabric Provider APIs

- Each fabric device type is implemented as a kfabric device provider module.

- kfi_provider_register()
  During kfabric provider module load, a call to kfi_provider_register() supplies the kgabric API with dispatch vectors for fi_* calls to the provider specific routines.

- kfi_provider_deregister()
  During kfabric provider module unload, kfi_provider_deregister() destroys the fi_* runtime linkage for the specific provider (ref counted).

Why a Kernel Storage Fabric Mid-Layer

- **Reliable sockets is a byte streaming interface**
  - Semantics do not map well to messaging operations (i.e. msg markers required)
    - kfabric complements sockets by providing a reliable message service
  - And sockets does not scale well in time or space
    - Polling connections for progress or memory consumption per connection

- **Kernel verbs is a low-level device driver I/F**
  - Not just an complicated interface, but also wire protocols (IB, RoCE, iWarp)
  - Lacking stronger completion semantics (i.e. data resides within a persistence domain)
  - kfabric is expected to call kverbs for certain networks

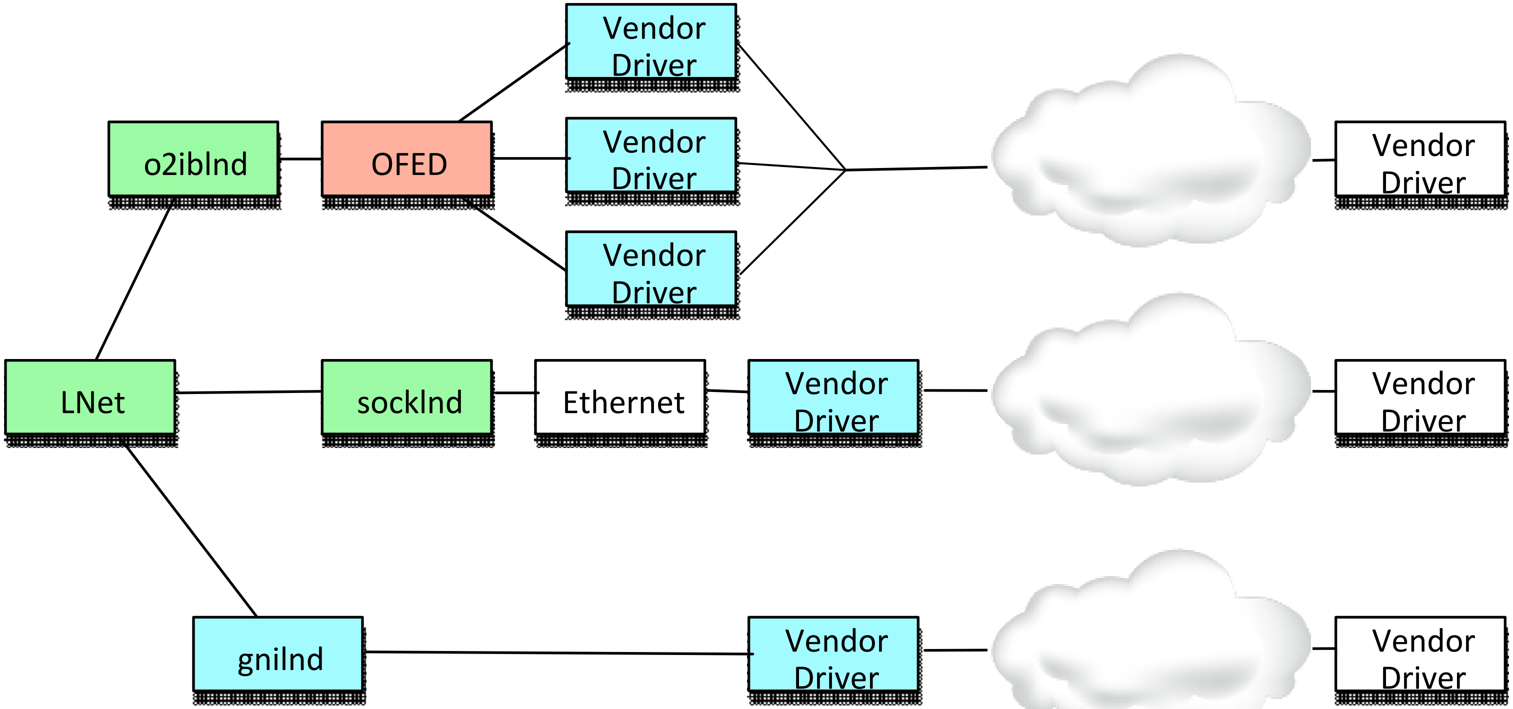
- **An RMA device agnostic fabric mid-layer does not exist today**

The semantics desired by current and emerging storage applications are not completely addressed by current APIs

Why a Kernel Storage Fabric Mid-Layer 2

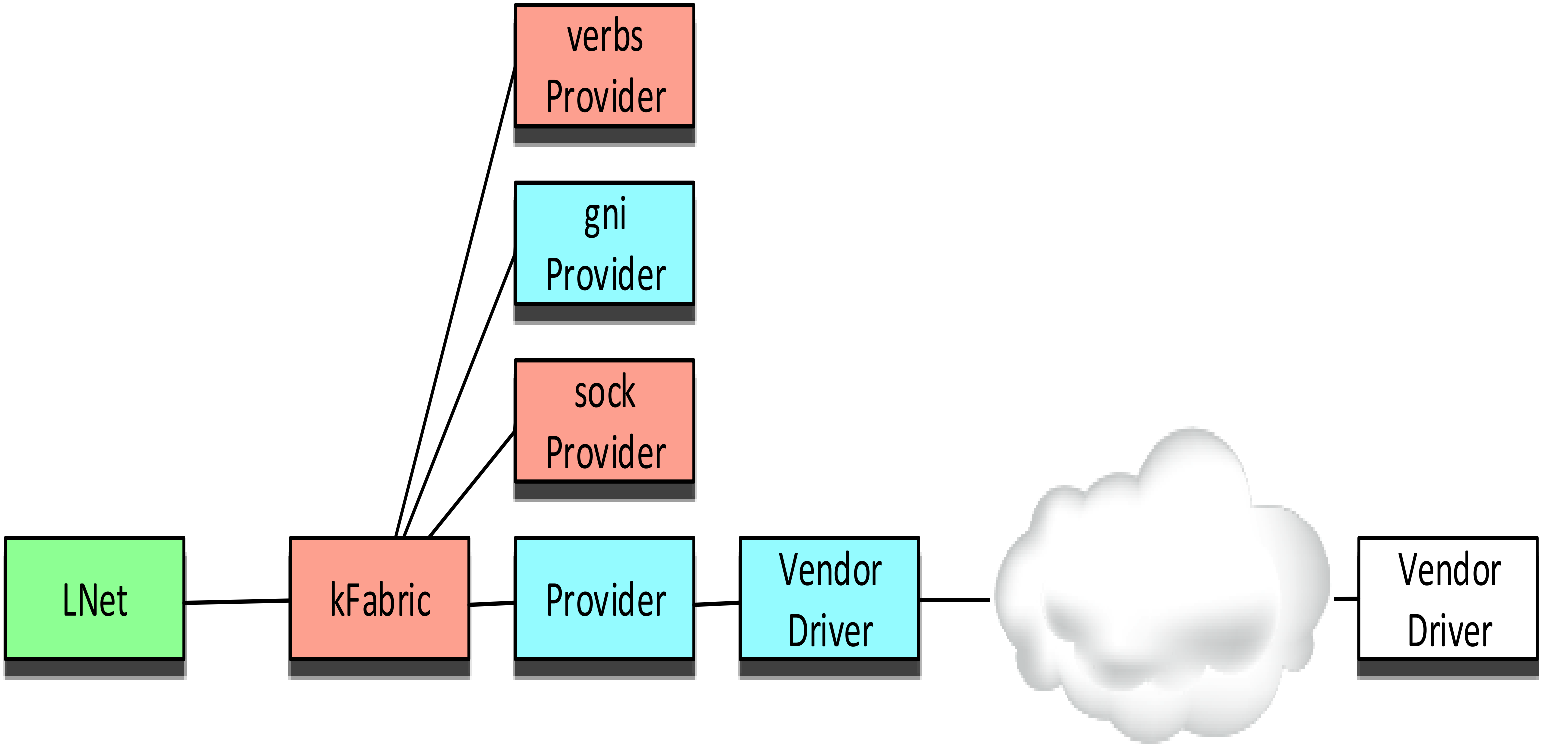
- **Block and object storage protocols map well to reliable message-based APIs that provide RMA services**
- **kfabric provides reliable and unreliable message services**
  - Fabric clients do not need to maintain message markers
- **kfabric does not require implicit buffering**
- **kfabric completion semantics are a semantic match with storage requirements**
  - e.g. Completions: local, remote, persistent, ordered and out-of-order data delivery…
- **kfabric endpoints are thread-safe (when requested)**
  - Multiple threads can make forward progress independently
  - Serialization can be done by the provider, not by the application/ULP
- **kfabric provides one-sided semantics enabling hardware Remote Memory Access without remote CPU intervention**

Current Lustre LND Architecture



🟩 Supported by Lustre Community
🟦 Supported by HW Vendors
🟥 Supported by OpenFabrics Community

Future Lustre LND Architecture



🟩 Supported by Lustre Community

🟦 Supported by HW Vendors

🟥 Supported by OpenFabrics Community

OPENFABRICS ALLIANCE

12th ANNUAL WORKSHOP 2016

THANK YOU

OFIWG – DS/DA