CCI

Common Communication Interface

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Applications are increasingly data-driven distributed services.

- These applications may control only one side of the pipe…
  - Common language: IP on the wire, Socket interface on the host.
  - Applications: web services, media delivery, trading exchange.
  - Not going away, way too much legacy.
- Or both sides of the pipe
  - No required wire protocol or programing interface.
  - Applications: back-ends, database, storage
    - Memcached, Big Table, Cassandra.
  - Socket interface hinders networking innovation.
  - Many vendor-specific interfaces available (dead or alive).

What if you control both sides ?

- Application developers either:
  - Stick with Sockets.
    - See substantially less benefit from current generation network technologies.
  - Lock themselves with a vendor-specific interface.
  - Support a number of different interfaces.
    - Requires deep expertise in multiple low-level network APIs
- Network vendors either:
  - Port Sockets on their low-level interface.
    - Limited performance.
  - Push their interface as the solution.
    - Everybody loves a good lock-in.
  - Support a number of different applications.
    - High support costs relative to potential revenue for niche applications.

Sockets

- Most widely used
  - Simple API
  - Robustness (failure tolerant)
  - Implicit buffering
  - Ubiquitous
- Unable to exploit many of the features of current-generation networking technologies
  - Cannot support zero-copy
  - Does not scale
    - In time: linear polling or interrupts.
    - In space: per socket resources.

MPI

- Designed as a bridge between application developers' and network vendors' needs in the High Performance Computing market
  - Standardization began nearly two decades ago
- MPI is the de-facto standard in HPC, Why not elsewhere?
  - High level of complexity
    - 200+ functions in MPI-1, 300+ in MPI-2
  - Original standard ignored dynamic environments
    - Added later but not widely adopted
  - Rigid fault model
    - Common fault case is abort execution of entire distributed application
    - Robust fault tolerance requires use of MPI dynamic process management (see above)

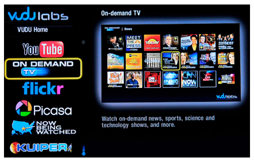
Specialized APIs abound

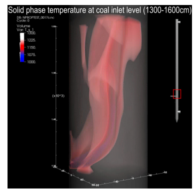
- OFA Verbs
  - High level of complexity, vendor lock-in is a concern
- Cray/Sandia's Portals
  - Highly specialized interface targeted towards HPC (MPI, SHMEM, UPC)
- Qlogics's PSM
  - Highly specialized interface targeted towards MPI
- Myricom's MX
  - Highly specialized interface targeted towards MPI
- IBM's LAPI and DCMF
  - Limited support outside of IBM network technologies
- DAPL
  - Limited support outside of iWARP capable devices
- LBL's GASnet
  - Designed specifically for the needs of UPC
- ARMCI
  - Designed specifically for the needs of Global Arrays
- LNET
  - Designed specifically for the needs of Lustre.
- BMI
  - Designed specifically for the needs of PVFS

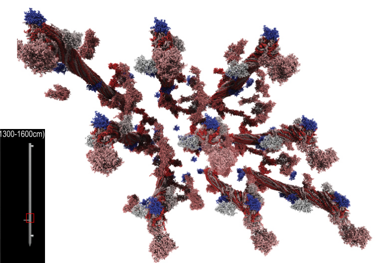
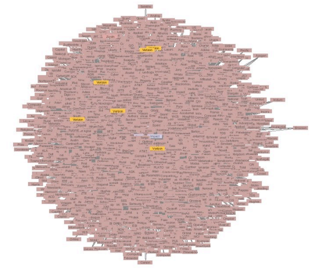
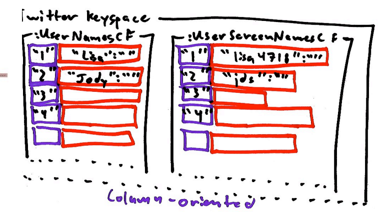
Summing up the landscape

	Sockets	MPI	Specialized APIs
Portability	✔	✔	✗
Simplicity	✔	✗	Varies
Performance	✗	✔	✔
Scalability	✗	✔	Varies
Robustness	✔	✗	Varies

Bridging two communities



Application Developers

Networking Technology
Vendors

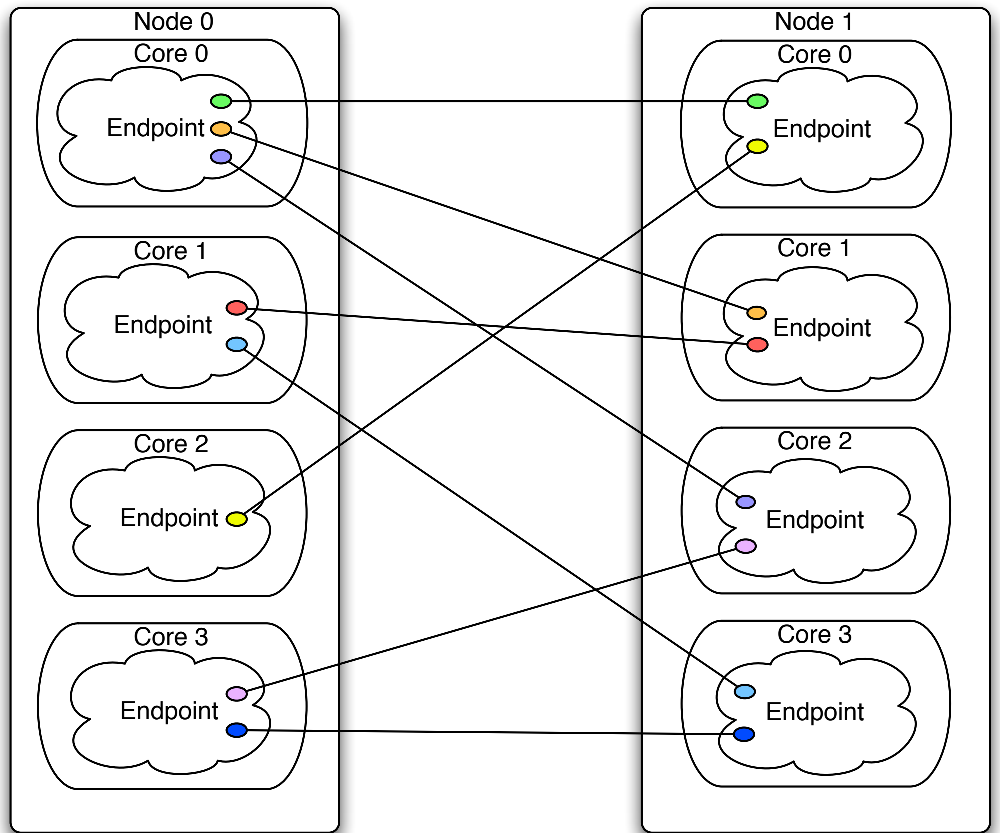



CCI design goals

- Performance
  - Can leverage OS-bypass, zero-copy, one-sided, async ops.
- Portability
  - Developers have limited resources.
  - Avoid vendor lock-in through a vendor neutral API.
- Simplicity
  - Must not be so complicated that only experts can use it.
  - Complexity tends to increase code size and maintenance cost.
- Scalability
  - Dynamic process management: peers come and go – not statically known a priori.
  - Time (polling) and space (buffer) cannot grow linearly with number of peers.
- Robustness
  - Need to contain faults to a single peer (i.e. fault isolation).

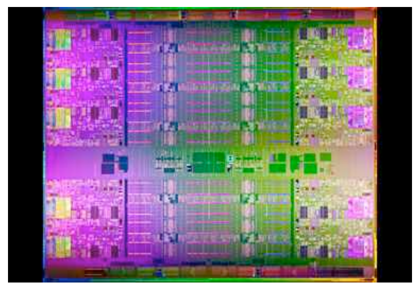
CCI Overview

- Endpoints
- Connections
- Communication
  - Active Messages
  - Remote Memory Access



CCI Endpoints

- Virtualized instance of a device – src/sink of communication
- Complete container of resources – queues and buffers
- An event driven model
  – Application may poll or block
  – Events include send, recv, connection establishment, etc.
  – Events may contain resources such as buffers
    - Resource ownership transfers to the application when the event is retrieved
  – May be returned out of order



Intel E7

CCI Connections

- Per peer - a single endpoint can handle many connections
- Scalable
  - no per-peer send/recv buffers
  - no per-peer event queues
- May have multiple connections to the same peer
- Use client/server connection model similar to Sockets
- Represents reliability and order attributes
  - Reliable with Ordered completion (RO)
  - Reliable with Unordered completion (RU)
  - Unreliable with Unordered completion (UU)
    - Multicast Send (MC_TX)
    - Multicast Receive (MC_RX)

Facebook data center

Active Messages

- Always buffered on both send and receive side
- Library manages buffers, not the application
- Events only, no handlers on receives
  - True handlers are the devil incarnate
  - Event includes pointer to data and the connection (peer)
- Message may be processed in-place
  - Even forwarded in-place
- May be copied out if needed long term
- Limited in size
  - Ideally MTU size to avoid segmenting/reassembly

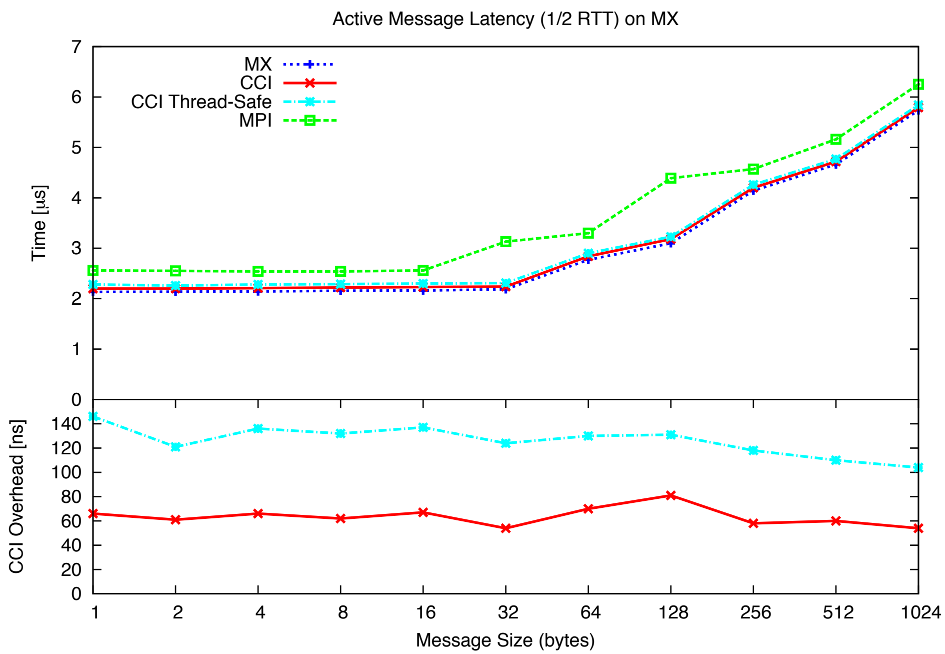
Remote Memory Access (RMA)

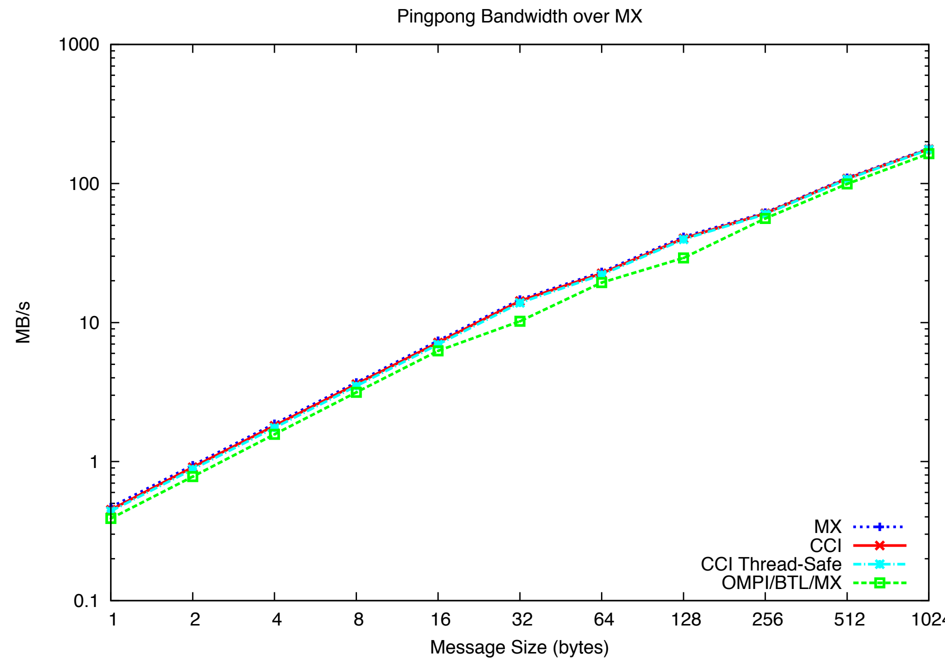
- RMA communication for bulk-data transfer
  - Zero-copy when available
  - One-sided operation
  - Active message model used for RMA synchronization
- Requires explicit memory registration
  - Provides broad portability
  - Simplified security model
- No intra-message or inter-message order guarantee
  - No last byte written last
- Optional inter-message ordering fence
- May be combined with immediate delivery of AM

Status and Evaluation

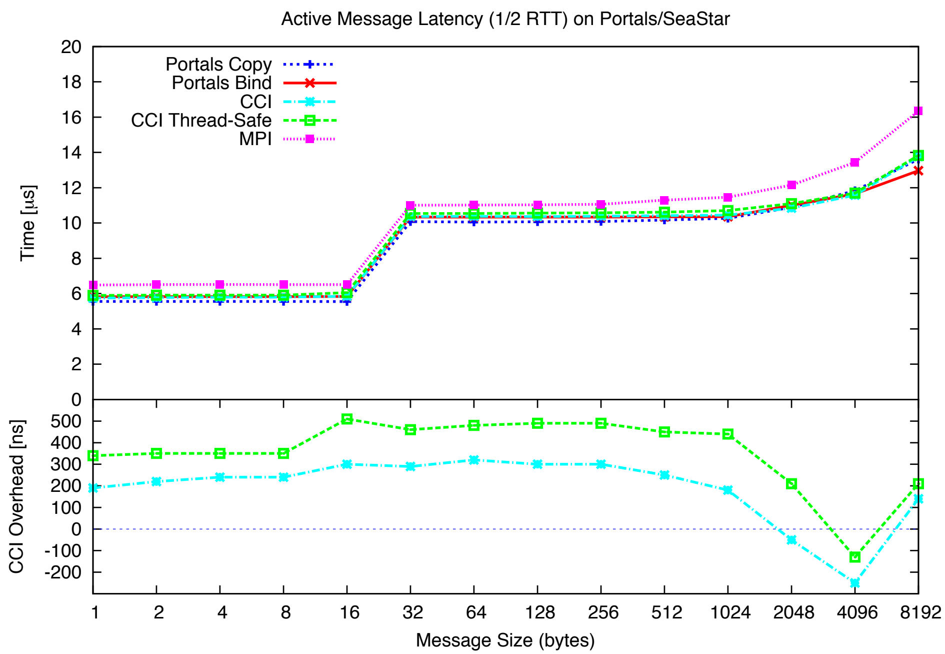
- ~~Three~~ Four proof-of-concept implementations
  - Sockets, MX, Portals 3.3, Native SeaStar
- Sockets
  - Uses UDP with one socket per endpoint, Implements reliability when required
  - Implements AM, RMA Write
- MX
  - Implements AM only
- Portals 3.3
  - Implements multiple endpoints using match bits
  - Implements AM, RMA Write, Read, and Fence
- Native SeaStar
  - Implements AM only
  - Working on adding RMA

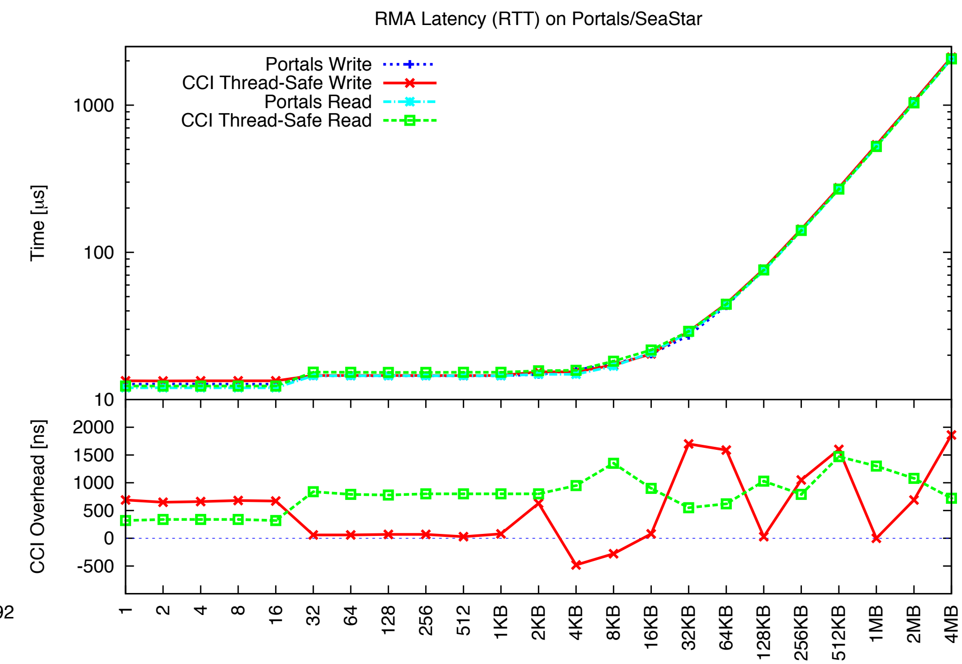
CCI/MX Performance



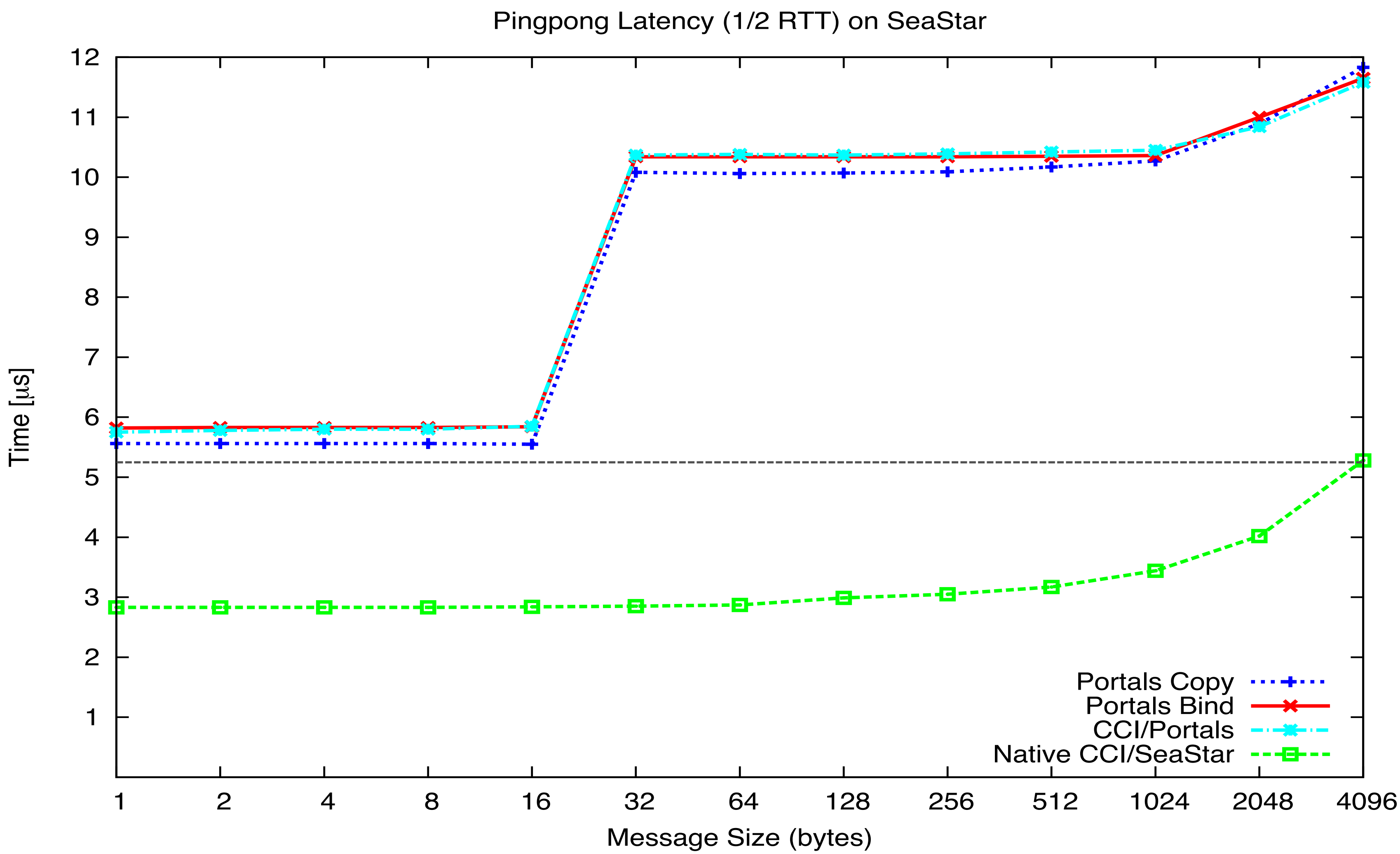


CCI/Portals Performance





Native SeaStar Performance



Caveats: Portals provides matching and thread-safety
Portals running on CNL, not Catamount
CCI/SS may require progress thread

Benefits of a common bridge

Application Developers

- Decrease complexity
- Port once, run everywhere
- Encourage competition among vendors
  - Fosters innovation
  - Improves cost effectiveness
- Mitigates technical and business risk of single vendor solution

Network Technology Vendors

- Increases total addressable market
  - Deliver performance to the masses
- Ability to expose innovation through a modern API
- Reduces costs
  - Eliminate per application support
  - Leverage community development of core API
  - Enables an ecosystem

Conclusion

- Distributed apps need
  - Performance - low latency, high throughput
  - To support transient peers and to isolate peer failures
  - To support large numbers of peers with bounded resources
  - Portable, simple programing interface
- CCI aims to satisfy these needs
  - Uses endpoints to bound time and space resources
  - Uses connections to provide peer fault isolation
  - Uses low-overhead active messages for small/control messages
  - Uses RMA for bulk movement and one-sided semantics
  - Provides good performance
  - Simple API
- CCI Next steps
  - Finish fleshing out TCP and native Portals implementations
  - Work is underway to provide Cray GNI, IBM Blue Gene, and InfiniBand Verbs support

Call for participation!

- We are a bunch of engineers
  - We don’t have a website
  - We don’t have a logo
  - We don’t have a glossy white-paper
  - But… We do have deep expertise in communication libraries
- We also have a community development model
  - Code is currently hosted on a private git-hub
  - License model is BSD/Apache style license
  - Contributor agreement is Apache style
- If you want to help contribute please contact us