ALFA - a common concurrency framework for ALICE and FAIR experiments

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ALFA: New ALICE-FAIR framework

- Motivation for ALFA
- ALFA and FairRoot
- Transport layer
- Serializing message data
- Deployment system
- Examples
- Summary

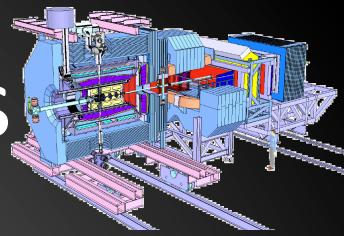
How it comes?

- FairRoot (2013)
  - Concurrency is an issue
  - Online and offline can (Should) be joined

- ALICE O^2 Project started (2013)
  - DAQ, Online and Offline : Together on one Framework

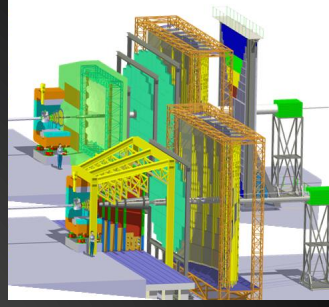
Similar online system requirements by ALICE and FAIR experiments

Online System Requirements PANDA



- Interaction rates of 20 MHz (50 MHz peak)
- Event size of 4-10 kB
- data rates after front end preprocessing: 80GB/s -300 GB/s
- No hardware trigger:
  - Autonomous recording frontends
  - Event selection in compute nodes

Online System Requirements CBM



- At 10 MHz, online data reduction by 1000 is mandatory (1 TB/s)
- Trigger signatures are complex (open charm) and require partial event reconstruction
- No a-priori association of signals to physical events!
- Need extremely fast reconstruction algorithms!

Online System Requirements ALICE Run3:

- Sample full 50kHz Pb-Pb interaction rate (current limit at ~500Hz, factor 100 increase)
- ⇨ ~1.1 TByte/s detector readout but the ALICE data processing power capacity will not allow more than a Storage bandwidth of ~20 GByte/s

Strategy

- Massive data volume reduction
  - Data reduction by (partial) online reconstruction and compression
- Much tighter coupling between online and offline reconstruction software

ALICE and FAIR: Why?

- A common framework will be beneficial for the FAIR experiments since it will be tested with real data and existing detectors before the start of the FAIR facility.
  - E.g.: Concepts for online calibrations and alignment can be tested in a real environment, similar to that of the planned FAIR experiments.

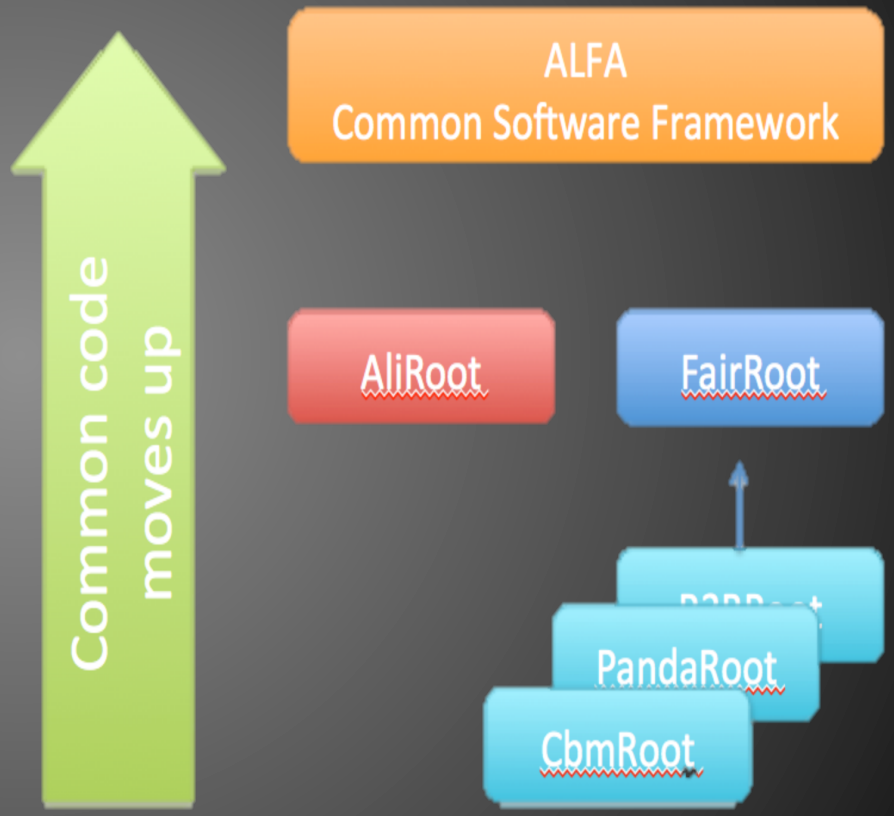
- ALICE will benefit from the work already performed by the FairRoot team concerning already implemented features (e.g. the continuous read-out, building and testing system, FairMQ, ..etc)

Who is going to collaborate on ALFA

- ALICE DAQ
- ALICE HLT
- ALICE Offline
- FairRoot
- Fair and Non-Fair experiments are welcome to join

ALFA

- Common layer for parallel processing.
- Common algorithms for data processing.
- Common treatment of conditions database.
- Common deployment and monitoring infrastructure.



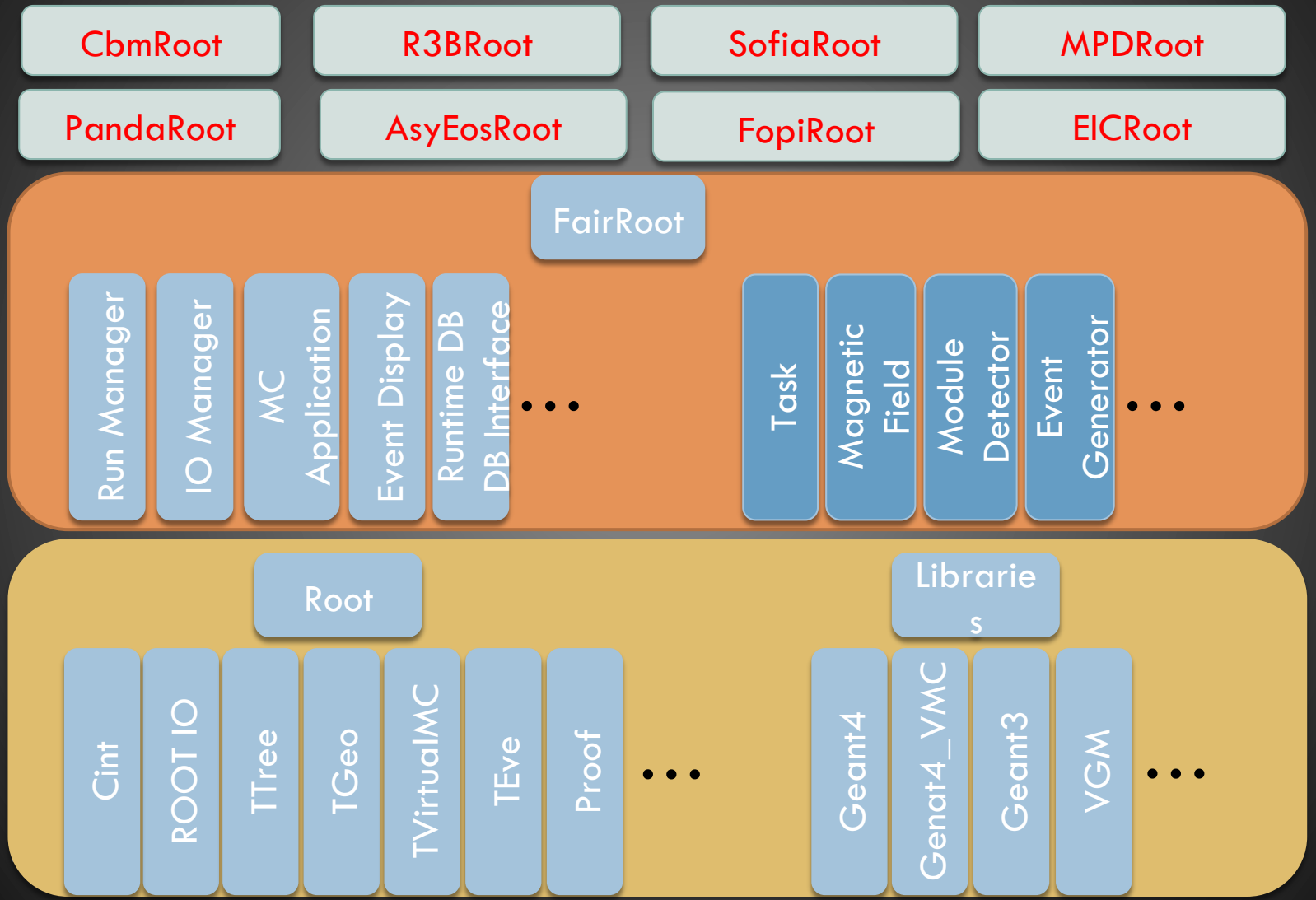
ALFA

- Will rely on a data-flow based model (Message Queues).
- It will contain
  - Transport layer (based on: ZeroMQ, NanoMSG)
  - Configuration tools
  - Management and monitoring tools
- Provide unified access to configuration parameters and databases.
- It will include support for a heterogeneous and distributed computing system.
- Incorporate common data processing components

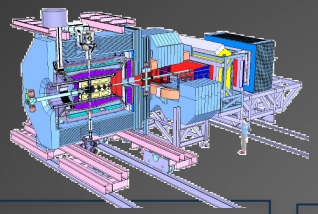
Correct balance between reliability and performance

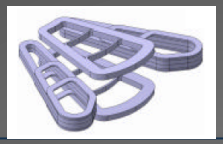
- Multi-process concept with message queues for data exchange
  - Each "Task" is a separate process, which can be also multithreaded, and the data exchange between the different tasks is done via messages.
  - Different topologies of tasks that can be adapted to the problem itself, and the hardware capabilities.

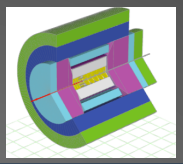
Current status of FairRoot

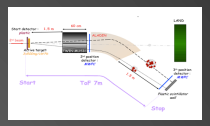


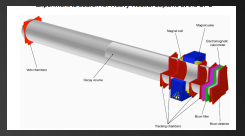
FairRoot











Start testing the VMC concept for CBM

Panda decided to join->

FairRoot: same Base package for different experiments

R3B joined

EIC (Electron Ion Collider BNL)

EICRoot

SOFIA (Studies On Fission with Aladin)

SHIP - Search for HIdden Particles

2004 | 2006 | 2010 | 2011 | 2012 | 2013 | 2014

First Release of CbmRoot

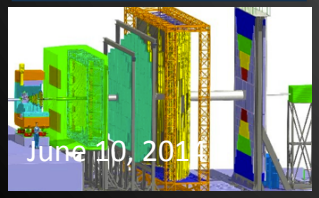
MPD (NICA) start also using FairRoot

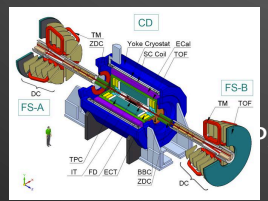
ASYEOS joined (ASYEOSRoot)

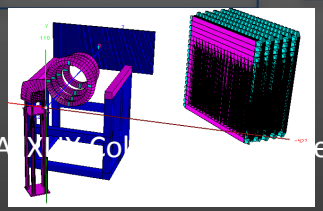
GEM-TPC seperated from PANDA branch (FOPIRoot)

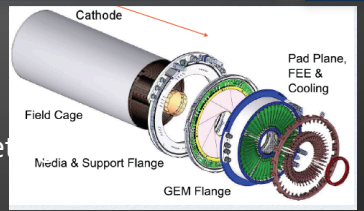
ENSAR-ROOT

Collection of modules used by structural nuclear phsyics exp.

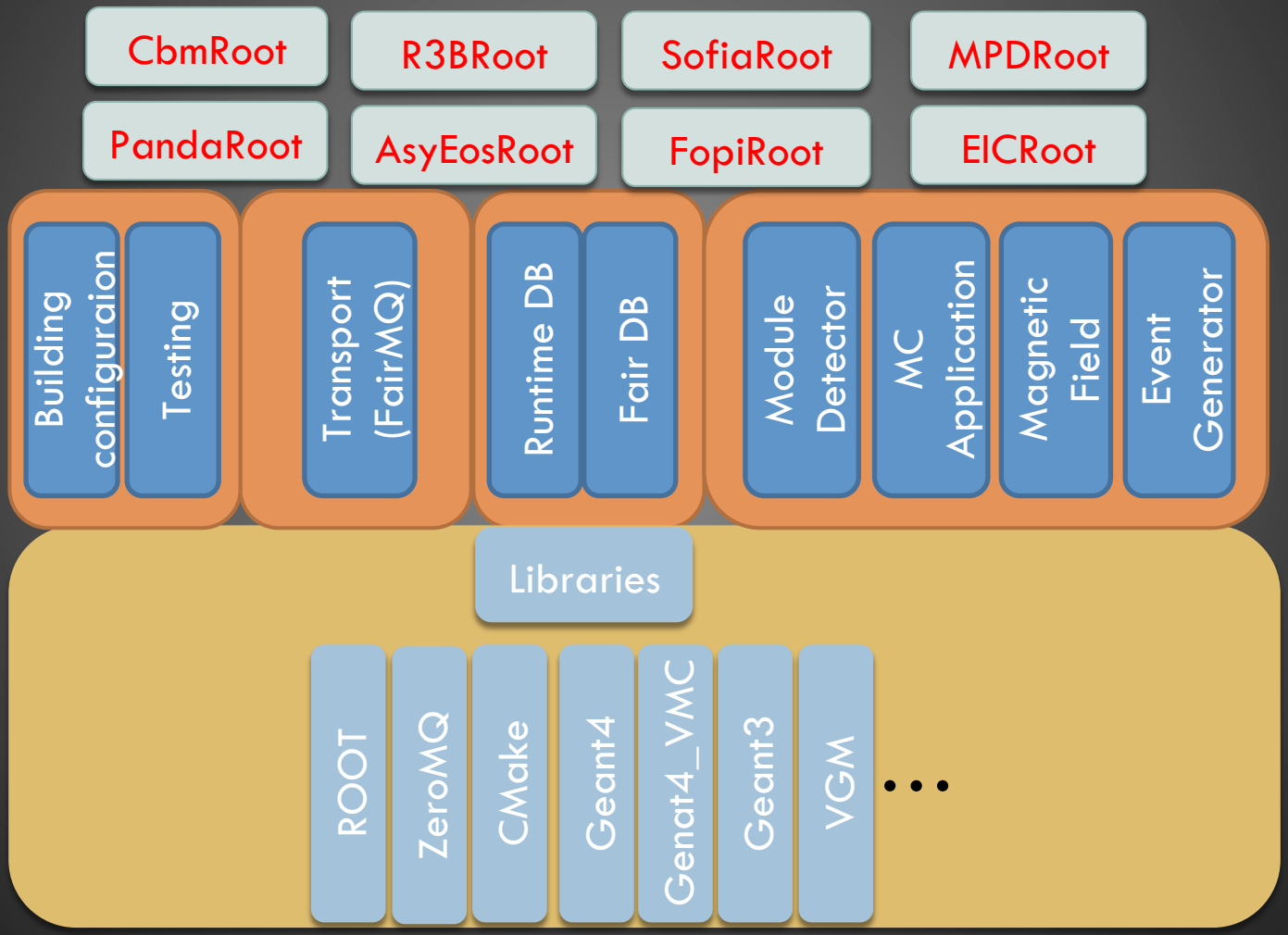




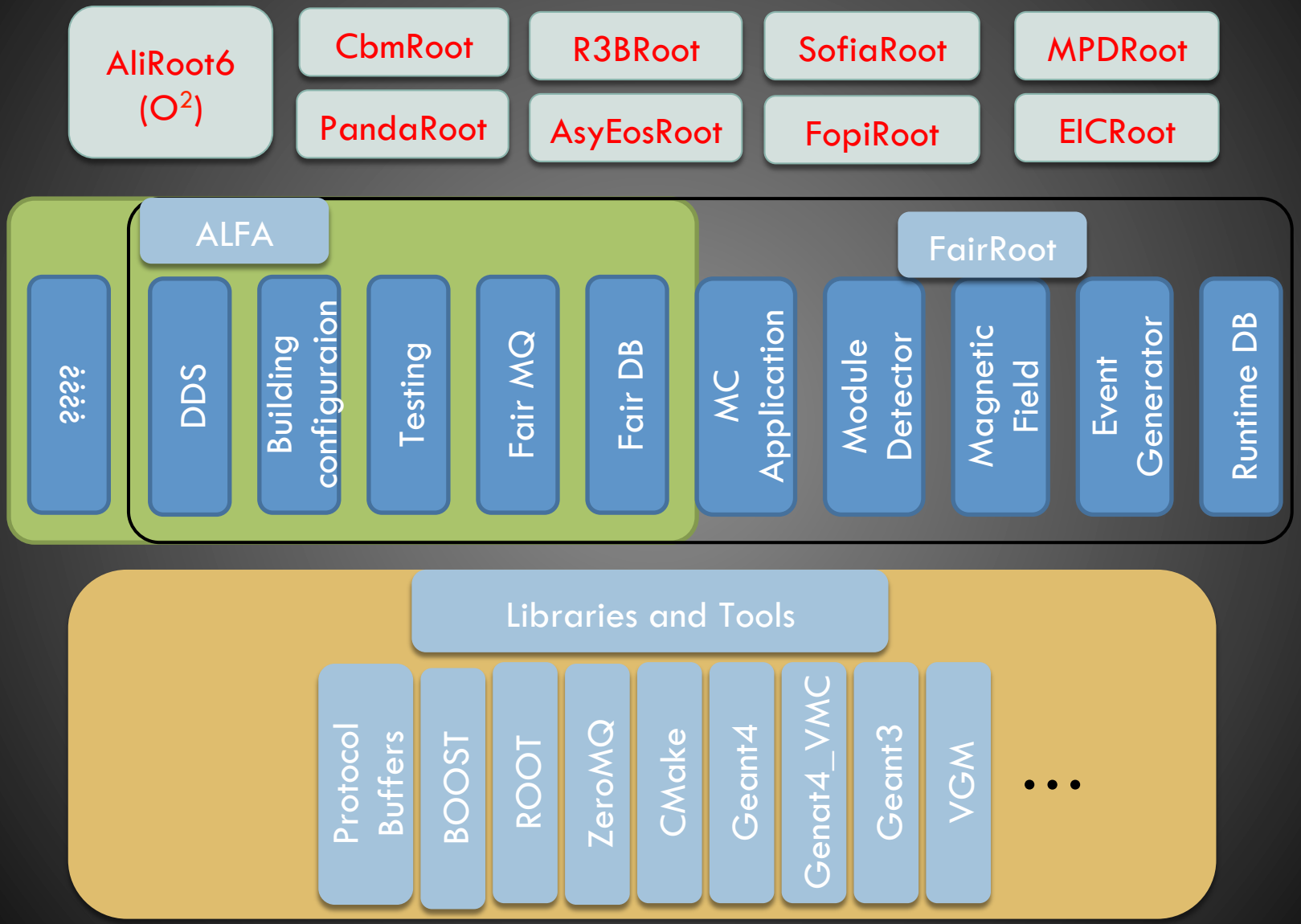




FairRoot is undergoing a re-design process to make it more modular

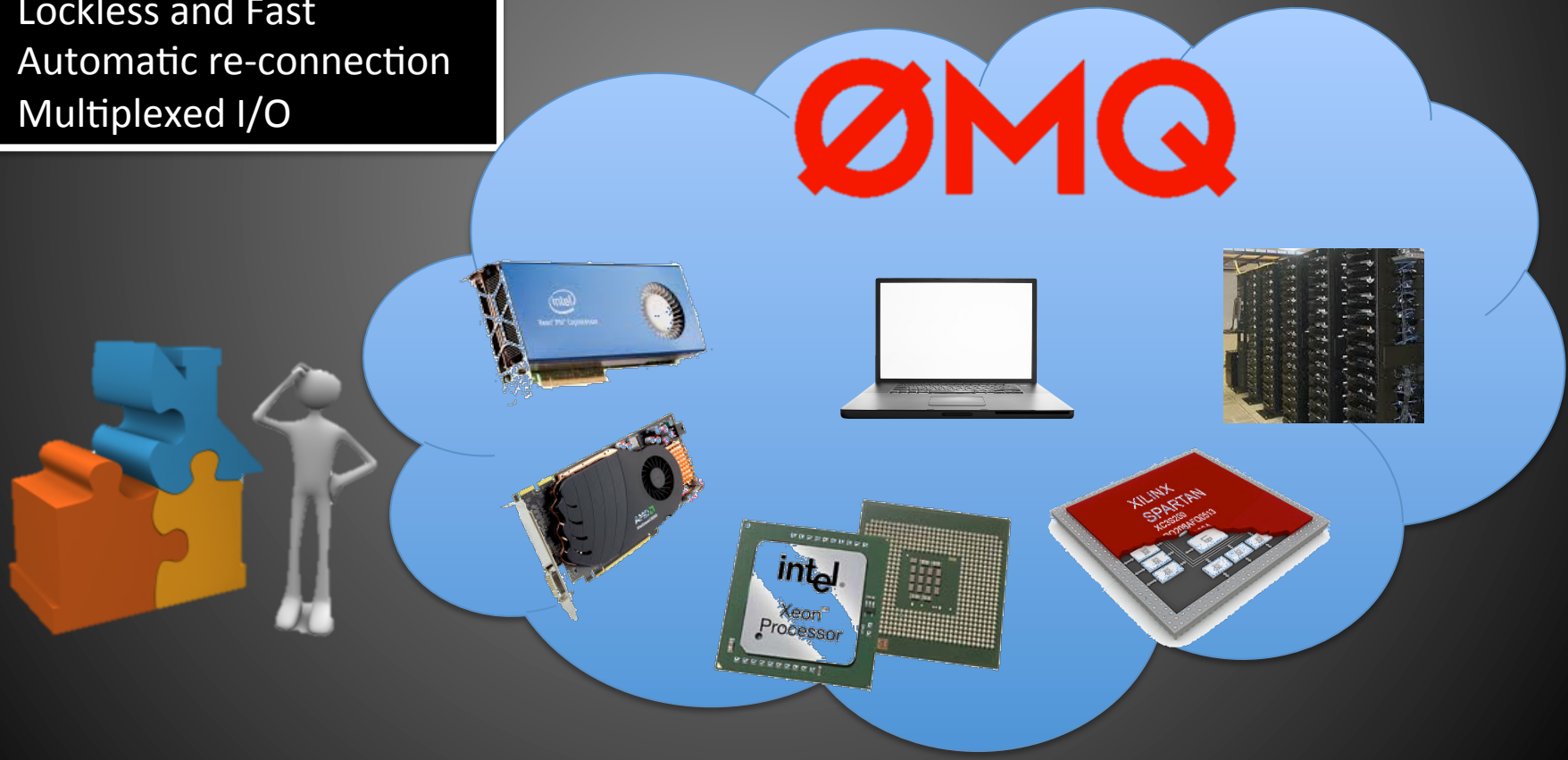


How is it with ALFA and FairRoot?



ALFA will use ZMQ to connect different pieces together

- BSD sockets API
- Bindings for 30+ languages
- Lockless and Fast
- Automatic re-connection
- Multiplexed I/O

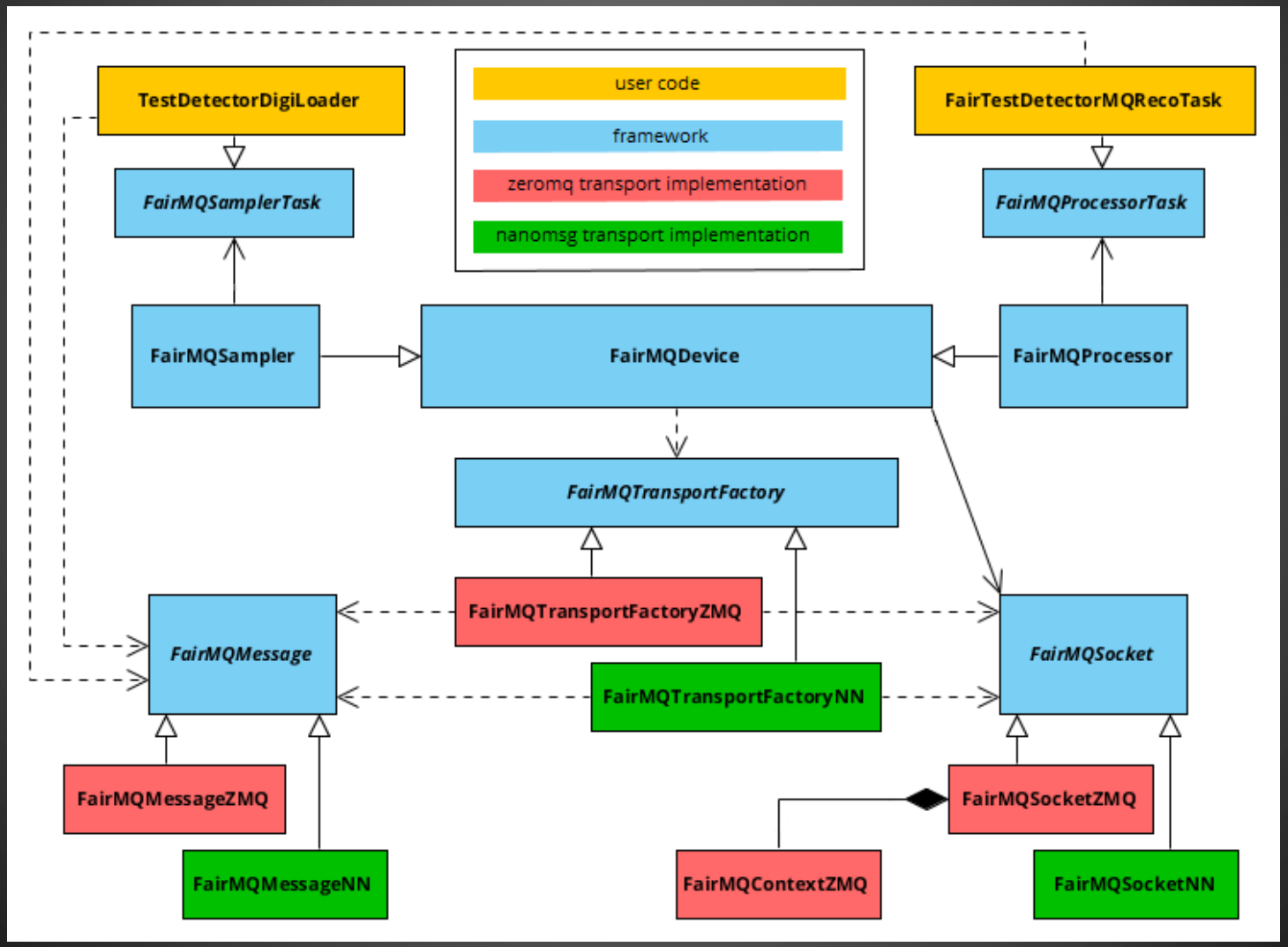


BUT: nanomsg is under development by the original author of ZeroMQ

nanomsg

- Pluggable Transports:
  - ZeroMQ has no formal API for adding new transports (Infiniband, WebSeockets, etc). nanomsg defines such API, which simplifies implementation of new transports.
- Zero-Copy:
  - Better zero-copy support with RDMA and shared memory, which will improve transfer rates for larger data for inter-process communication.
- Simpler interface:
  - simplifies some zeromq concepts and API, for example, it no longer needs Context class.
- Numerous other improvements, described here: http://nanomsg.org/documentation-zeromq.html
- FairRoot is independent from the transport library
  - Modular/Pluggable/Switchable transport libraries.

ALFA has an abstract transport layer



How the different processes are going to communicate with each other?

- Different languages and hardware are possible how should the data exchange be done?

- Schema evolution?

Protocol buffers

- Google Protocol Buffers support is now implemented
  - Example in Tutorial 3 in FairRoot.

- To use protobuf, run cmake as follows:
  - cmake -DUSE_PROTOBUF=1

Boost serialization

- Code portability - depend only on ANSI C++ facilities.
- Code economy - exploit features of C++ such as RTTI, templates, and multiple inheritance, etc. where appropriate to make code shorter and simpler to use.
- Independent versioning for each class definition. That is, when a class definition changed, older files can still be imported to the new version of the class.
- Deep pointer save and restore. That is, save and restore of pointers saves and restores the data pointed to.
- ….

http://www.boost.org/doc/libs/1_55_0/libs/serialization/doc/index.html

This is used already by the CBM Online group in Frankfurt and to we need it to exchange data with them!

Protobuf, Boost or Manual serialization?

- Boost:
  - we are generic in the tasks but intrusive in the data classes (digi, hit, timestamp)
- Manual and Protobuf
  - we are generic in the class but intrusive in the tasks (need to fill/access payloads from class with set/get x, y, z etc).

Manual method is still the fastest, protobuf is 20% slower and boost is 30% slower.

preliminary

How to deploy ALFA on a laptop, few PCs or a cluster?

- We need to utilize any RMS (Resource Management system)
- We should also run with out RMS
- Support different topologies and process dependencies

How to deploy ALFA on a laptop, few PCs or a cluster?

- We have to develop a dynamic deployment system (DDS):
  - An independent set of utilities and interfaces, which provide a dynamic distribution of different user processes by any given topology on any RMS.

The Dynamic Deployment System (DDS) Should:

- Deploy task or set of tasks
- Use (utilize) any RMS (Slurm, Grid Engine, …),
- Secure execution of nodes (watchdog),
- Support different topologies and task dependencies
- Support a central log engine
- ….

See Talk by Anar Manafov on Alice Offline week (March 2014)
https://indico.cern.ch/event/305441/

Elements of the topology

Task

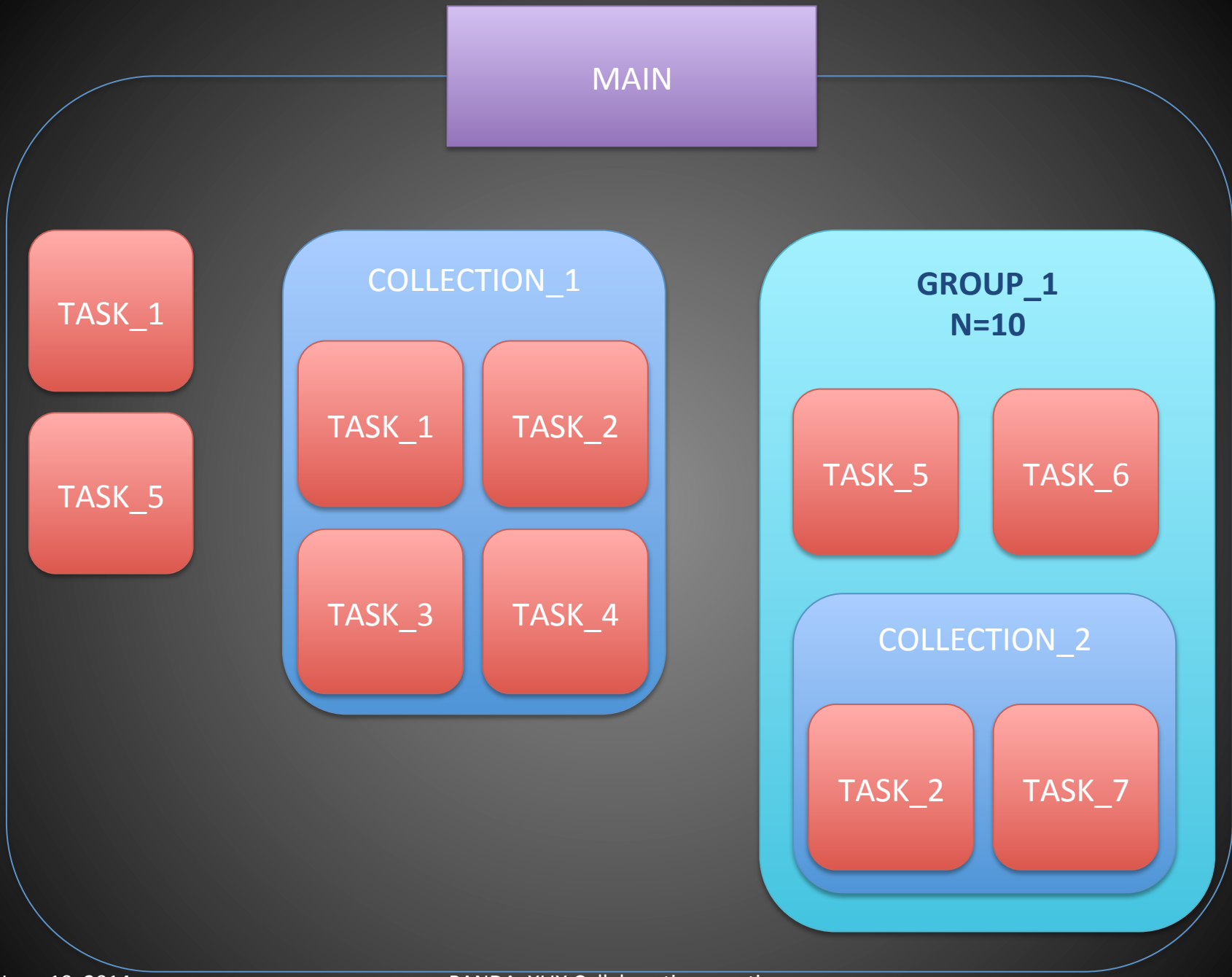
* A task is a single entity of the system.
* A task can be an executable or a script.
* A task is defined by a user with a set of props and rules.
* Each task will have a dedicated DDS watchdog process.

Collection

* A set of tasks that have to be executed on the same physical computing node.

Group

* A container for tasks and collections.
* Only main group can contain other groups.
* Only group define multiplication factor for all its daughter elements.


MAIN
TASK_1
TASK_5
COLLECTION_1
TASK_1
TASK_2
TASK_3
TASK_4
GROUP_1
N=10
TASK_5
TASK_6
COLLECTION_2
TASK_2
TASK_7

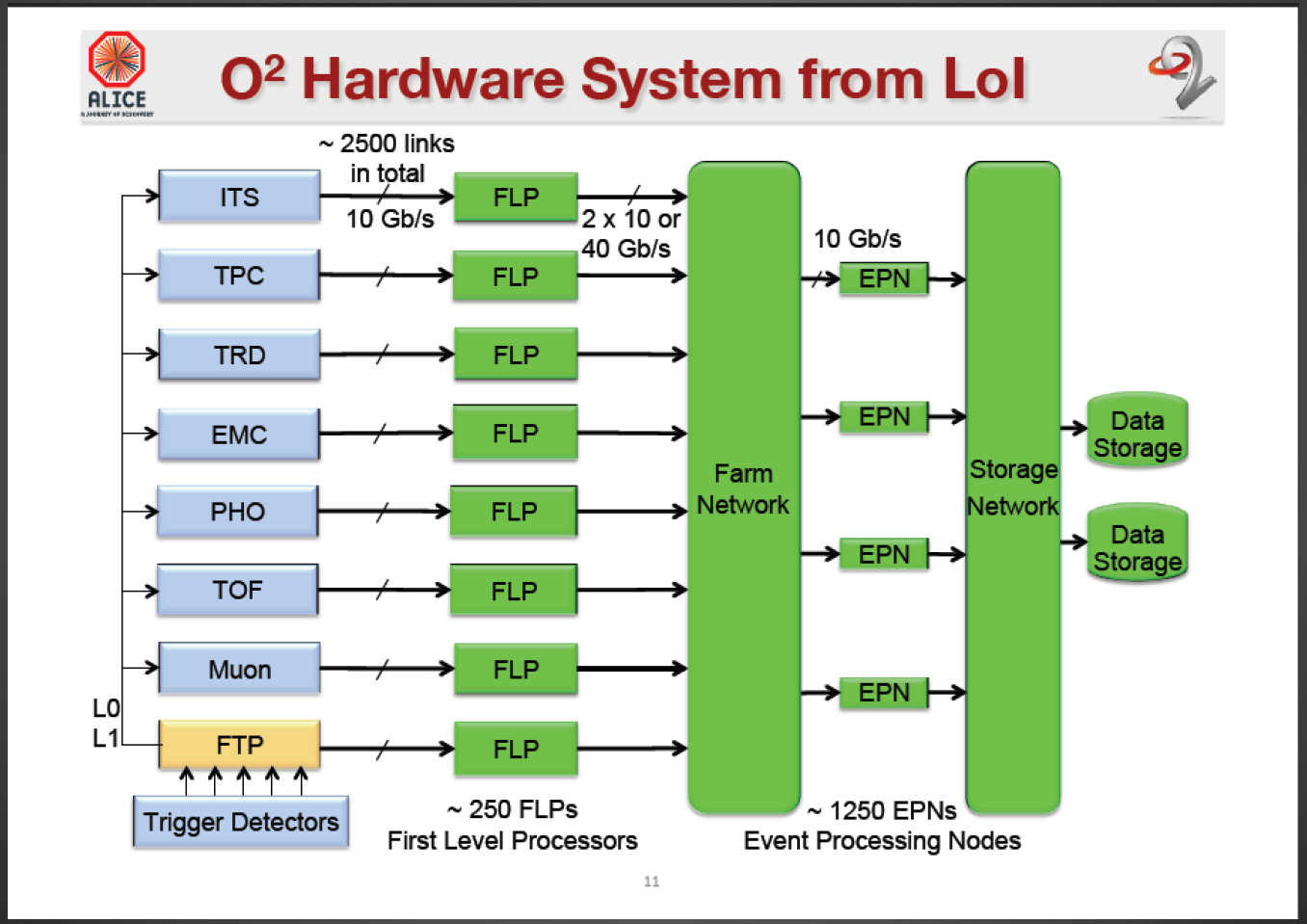
Current Status

- The Framework delivers some components which can be connected to each other in order to construct a processing pipeline(s).
- All components share a common base called Device
- Devices are grouped by three categories:
  - Source:
    - Data Readers (Simulated, raw)
  - Message-based Processor:
    - Sink, Splitter, Merger, Buffer, Proxy
  - Content-based Processor:
    - Processor

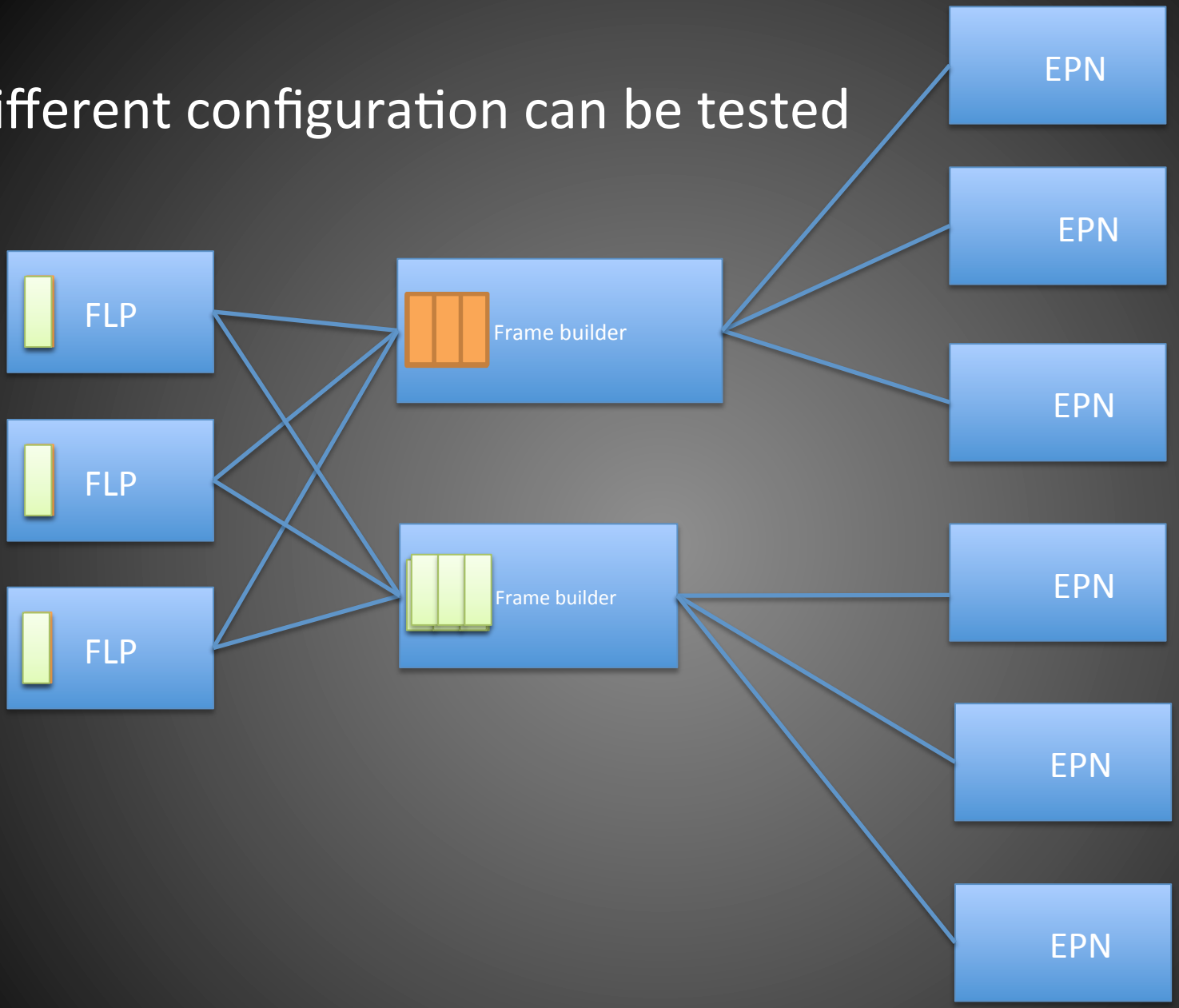
Using multi-part messages

- It allows us to concatenate multiple messages into a single message without copying
- All parts of the message are treated as a single atomic unit of transfer, however the boundaries between message parts are strictly preserved
- A multi-part message is a message that has more than one frame. ZeroMQ sends this message as a single on-the-wire message and guarantees to deliver all the message parts (one or more), or none of them.

We need a proto type for ALICE O2



Different configuration can be tested

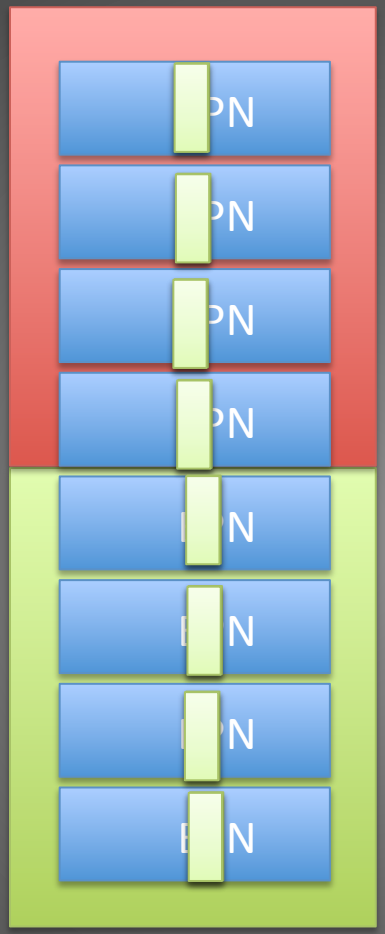


/local/home/cwg13/new_test_21.05.2014/single/startAll.sh

aidrefma02

aidrefma01

aidrefma04



aidrefma03

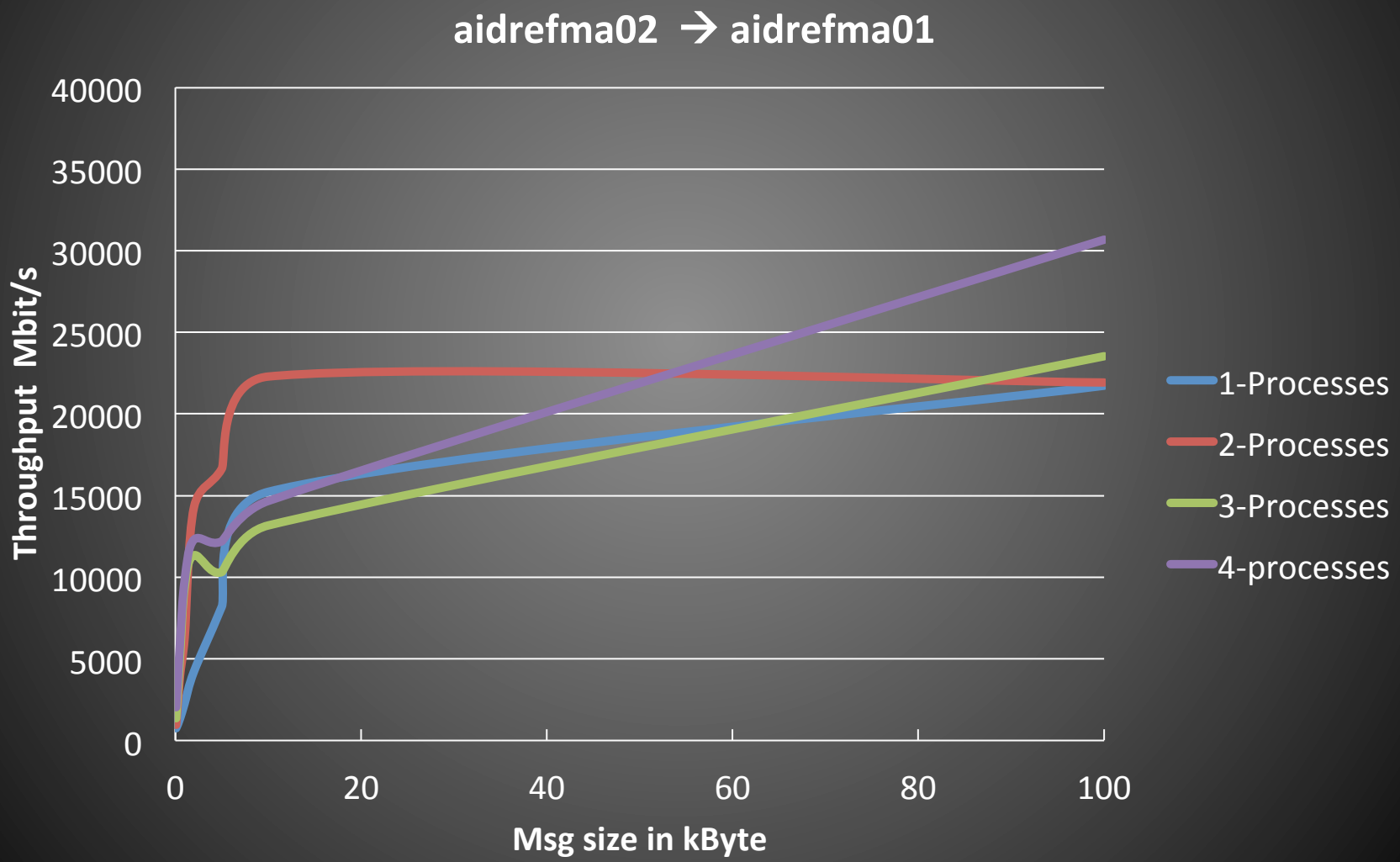
aidrefma06

aidrefma08

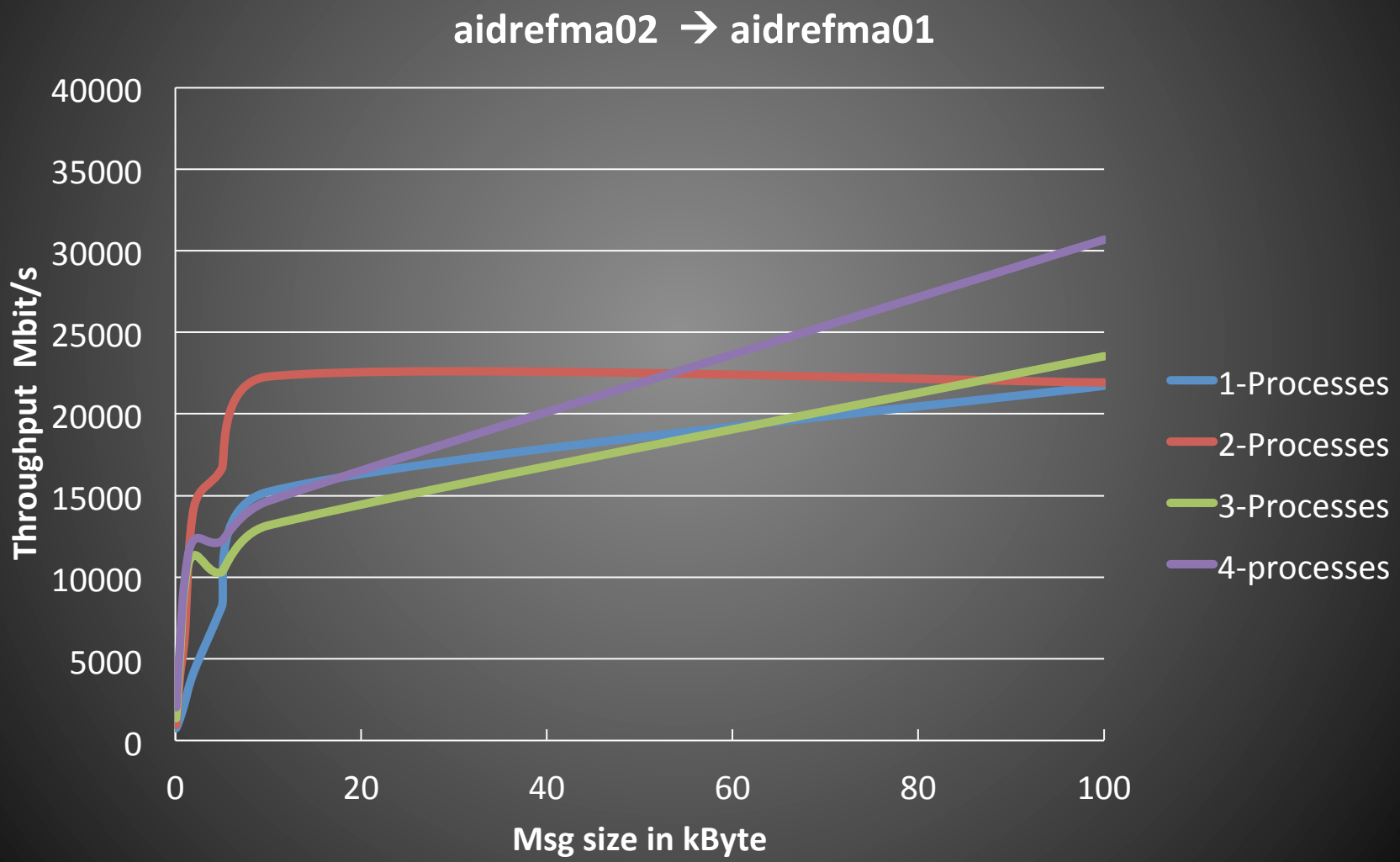
aidrefma05

aidrefma07

Running the Zero MQ performance test on the DAQ test cluster



Running the Zero MQ performance test on the DAQ test cluster



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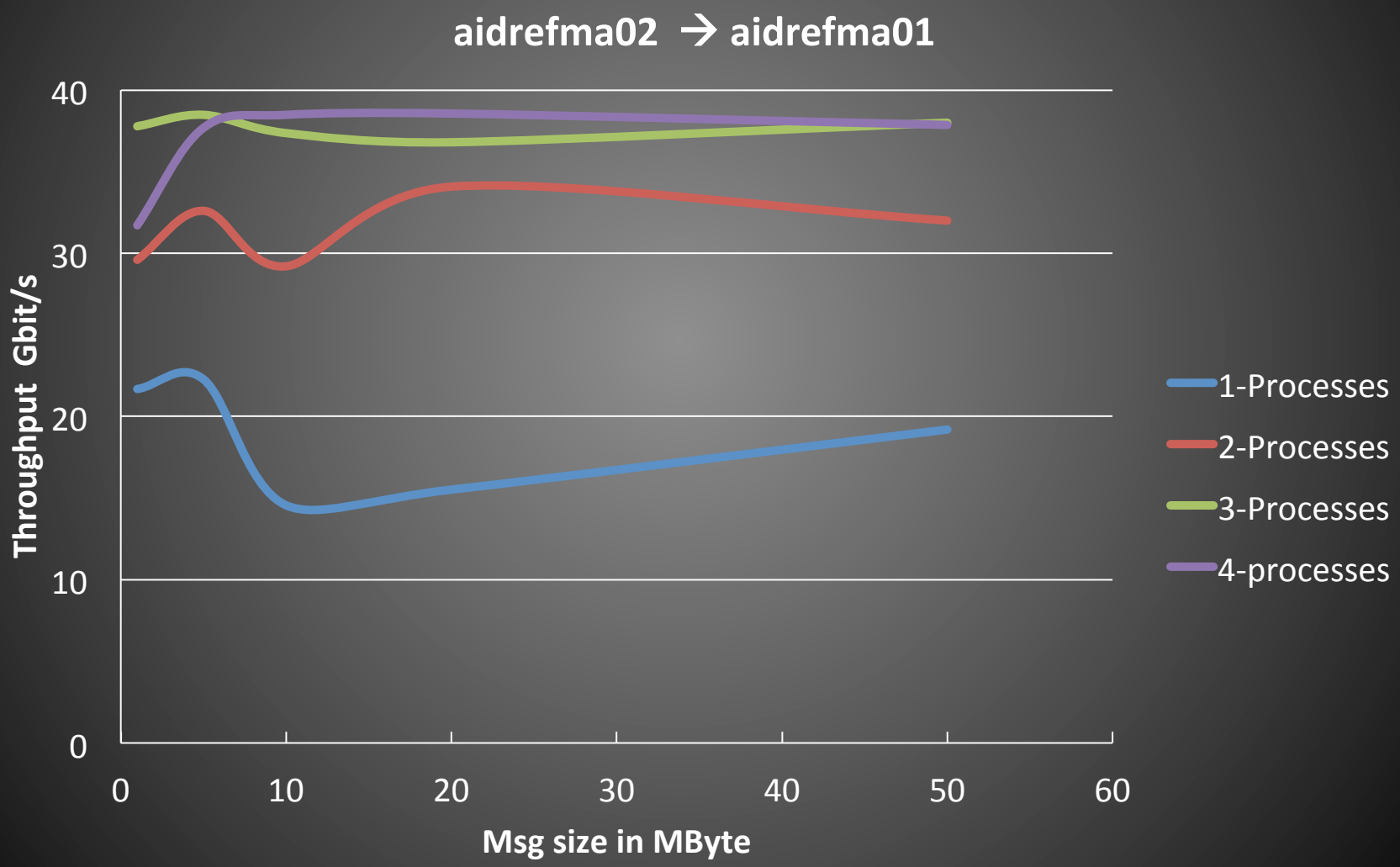

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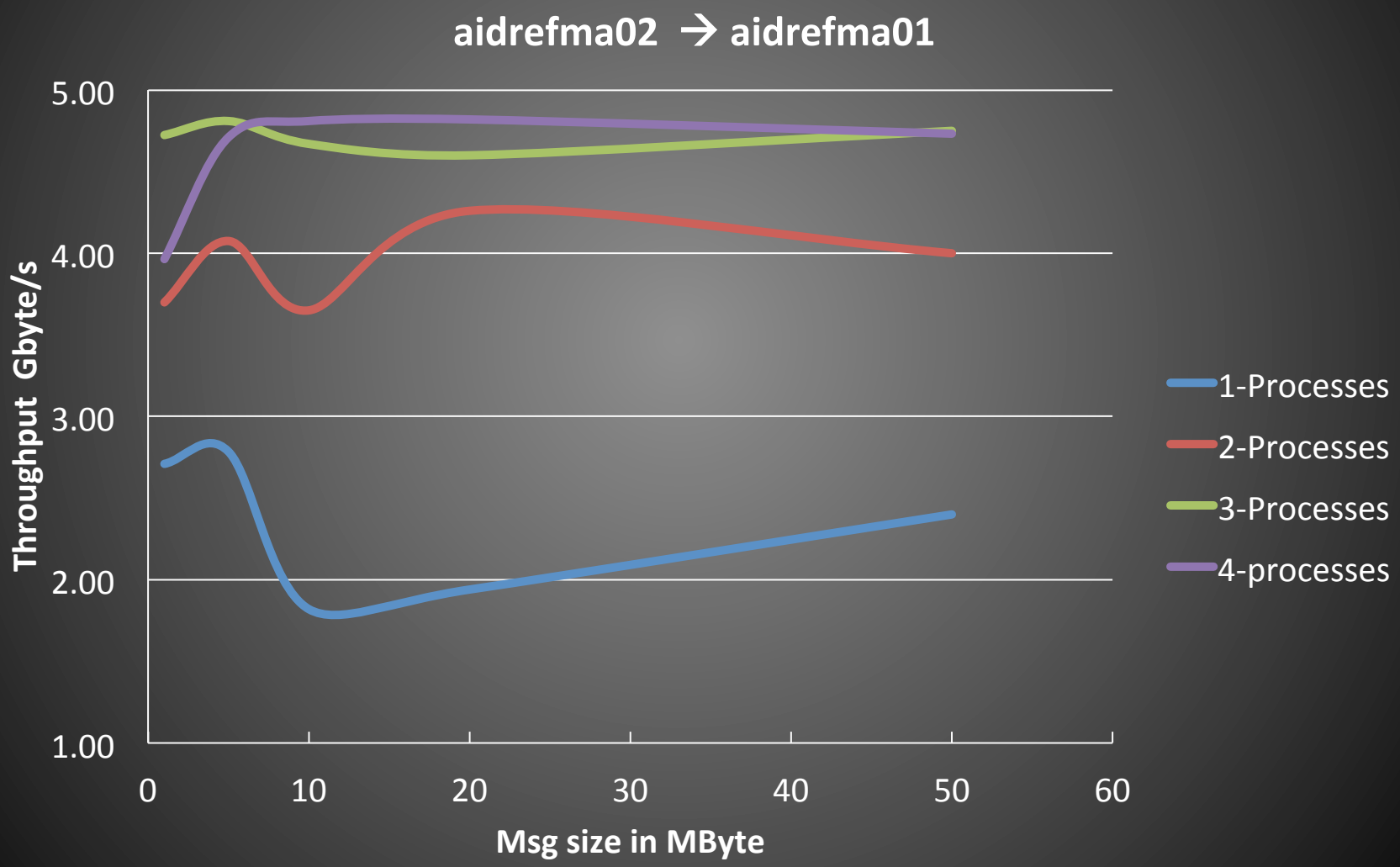


Performance test with FairMQ
FLP 2 EPN

Push-Pull pattern
Message size= 10 Mbyte
Throughput = 2,6 Gbyte/s

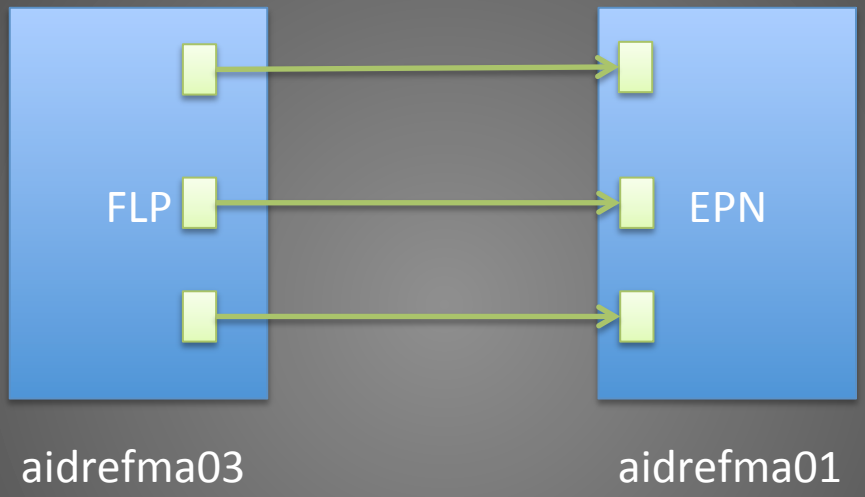
Performance test with FairMQ
FLP 2 EPN

aidrefma02

aidrefma01

Push-Pull pattern
Message size= 10 Mbyte
Throughput = 3,7 Gbyte/s

Performance test with FairMQ
FLP 2 EPN



Push-Pull pattern
Message size= 10 Mbyte
Throughput = 4,8 Gbyte/s

Summary

- The ALFA project is starting
- The Communication layer is ready to use
- Different data serialization methods are available
- DDS and Topology parser are under development first release is expected this month

Backup and Discussion

STORM is a very attractive option but no native support for C++ !

Storm was designed from the ground up to be usable with any programming language. At the core of Storm is a Thrift definition for defining and submitting topologies. Since Thrift can be used in any language, topologies can be defined and submitted from any language.

Similarly, spouts and bolts can be defined in any language. Non-JVM spouts and bolts communicate to Storm over a JSON-based protocol over stdin/stdout. Adapters that implement this protocol exist for Ruby, Python, Javascript, Perl, and PHP.

storm-starter has an example topology that implements one of the bolts in Python.

http://storm.incubator.apache.org/about/multi-language.html

The built-in core ØMQ patterns are:

- **Request-reply**, which connects a set of clients to a set of services. (remote procedure call and task distribution pattern)
- **Publish-subscribe**, which connects a set of publishers to a set of subscribers. (data distribution pattern)
- **Pipeline**, which connects nodes in a fan-out / fan-in pattern that can have multiple steps, and loops. (Parallel task distribution and collection pattern)
- **Exclusive pair**, which connect two sockets exclusively