Parallelization in Machine Learning with Multiple Processes

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http://oproject.org

ROOT
Data Analysis Framework

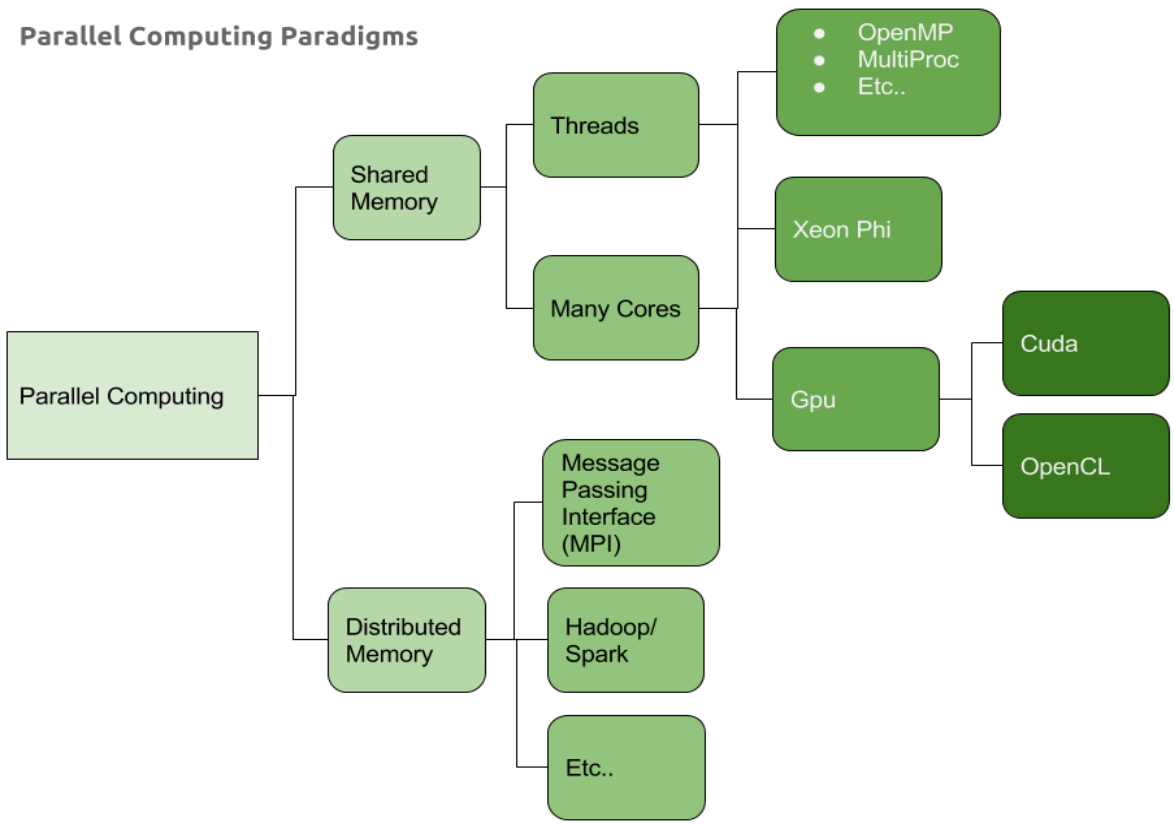
TMVA

Outline

- Parallel architectures
- ROOTMpi
  - MPI Current status and future
  - Implementation with ROOT
- TMVA
  - New architecture for paralelization
  - Parallelization prototype with MultiProc/MPI
- Conclusions

Parallel architectures

- Why parallel computing?
  - Huge amount of data
  - Expensive algorithms
- Which paradigm?
  - A lot



Message Passing Interface

- Standard of communication for HPC/Grid Computing
- Widely used in the scientific community.
- Implementations
  - OpenMPI, MPICH, IBM, Intel etc..
- Support for:
  - RMA (Remote Memory Access)
  - Shared memory
  - Checkpointing
  - P2P and collective communication
- Fault tolerance under develoment http://mpi-forum.org/mpi-40

ROOTMpi

Integration of MPI and ROOT technologies in a framework for parallel computing.

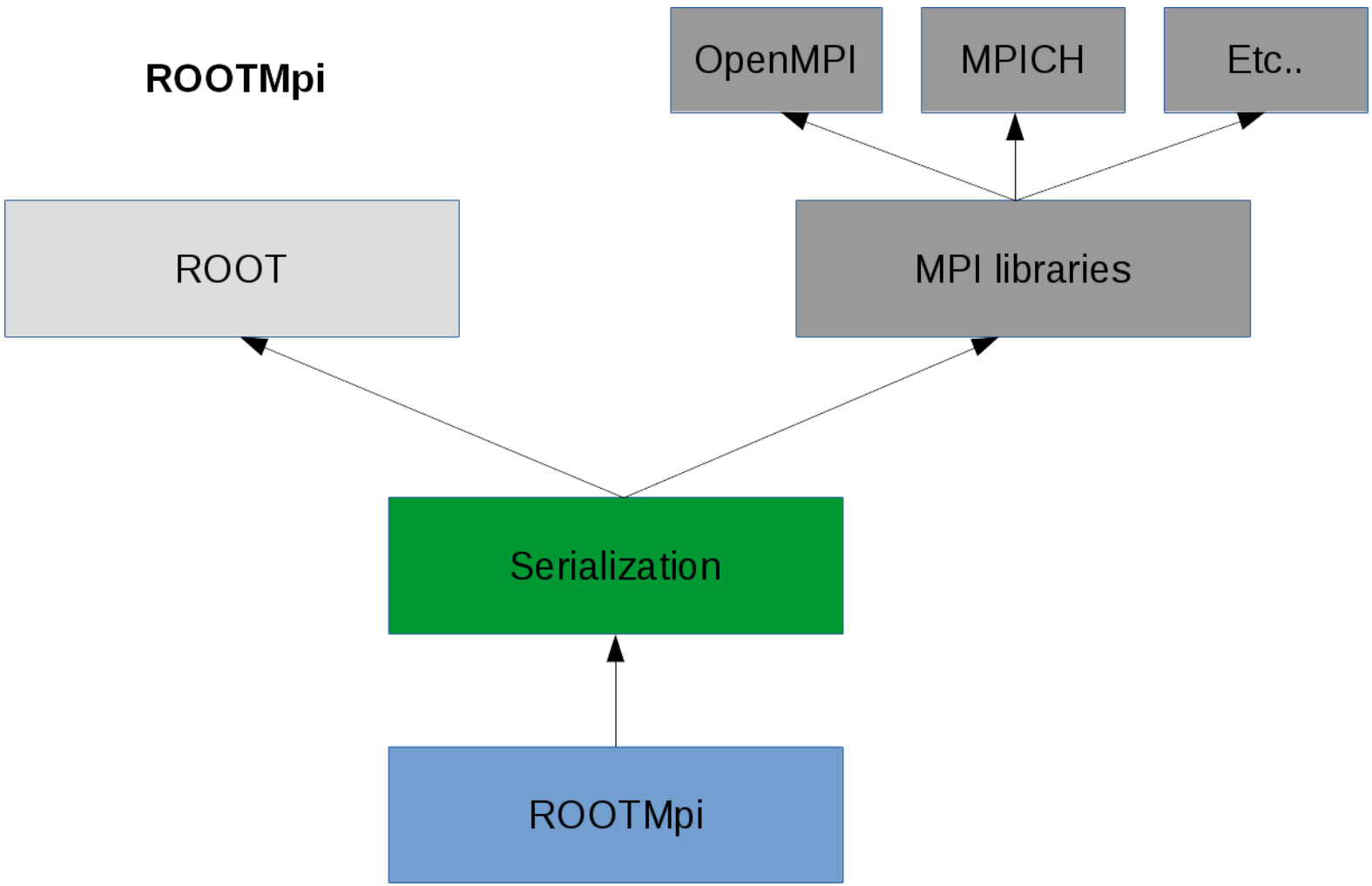
Motivation:

- Communicate ROOT objects through processes.
- Implement MPI with a better design for ROOT.
- Create an interface that uses the new C++ features to write parallel code.
- **Implement TMVA algorithms in parallel for HPC/Grid systems.**

ROOTMpi

- Prototype is going under development with the next features already implemented
  - Peer to Peer communication
  - Some collective operation implemented
    - Gather/AllGtaher
    - Scatter/AllScatter
    - Redude/AllReduce
    - Bcast
  - Communicators
    - IntraCommunicator
    - InterCommunicator
  - Blocking and non-blocking communication.
  - Tested with OpenMPI and MPICH

ROOTMpi Design



ROOTMpi Design Comparison with C

```
int array[size];
..
MPI_Send(array, size, MPI_INT, dest, tag, MPI_COMM_WORLD);
```

Pointer to void

Size of the array

Predefined MPI datatype

Message destination

Tag id

MPI Communicator

ROOTMpi Design Comparison with C

Send in ROOTMpi

```
std::vector<int> array(size);
..
COMM_WORLD.Send(array,dest,tag);
```

Global Communicator

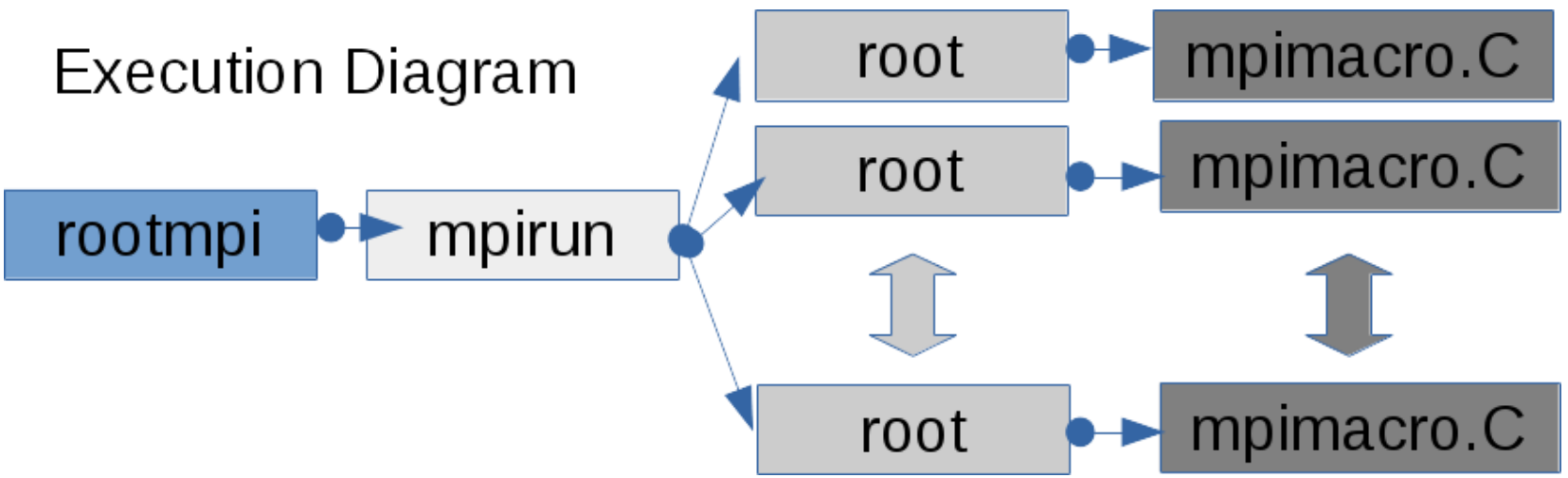
Template Method

Any serializable object

Message destination

Tag id

ROOTMpi Design




```
ozapatam@gfif:~$ rootmpi -np 2 -machinefile nodes hello.C
hello from process = 1 node = gfif-wn7
hello from process = 0 node = gfif-wn6
```

Example
Peer to Peer

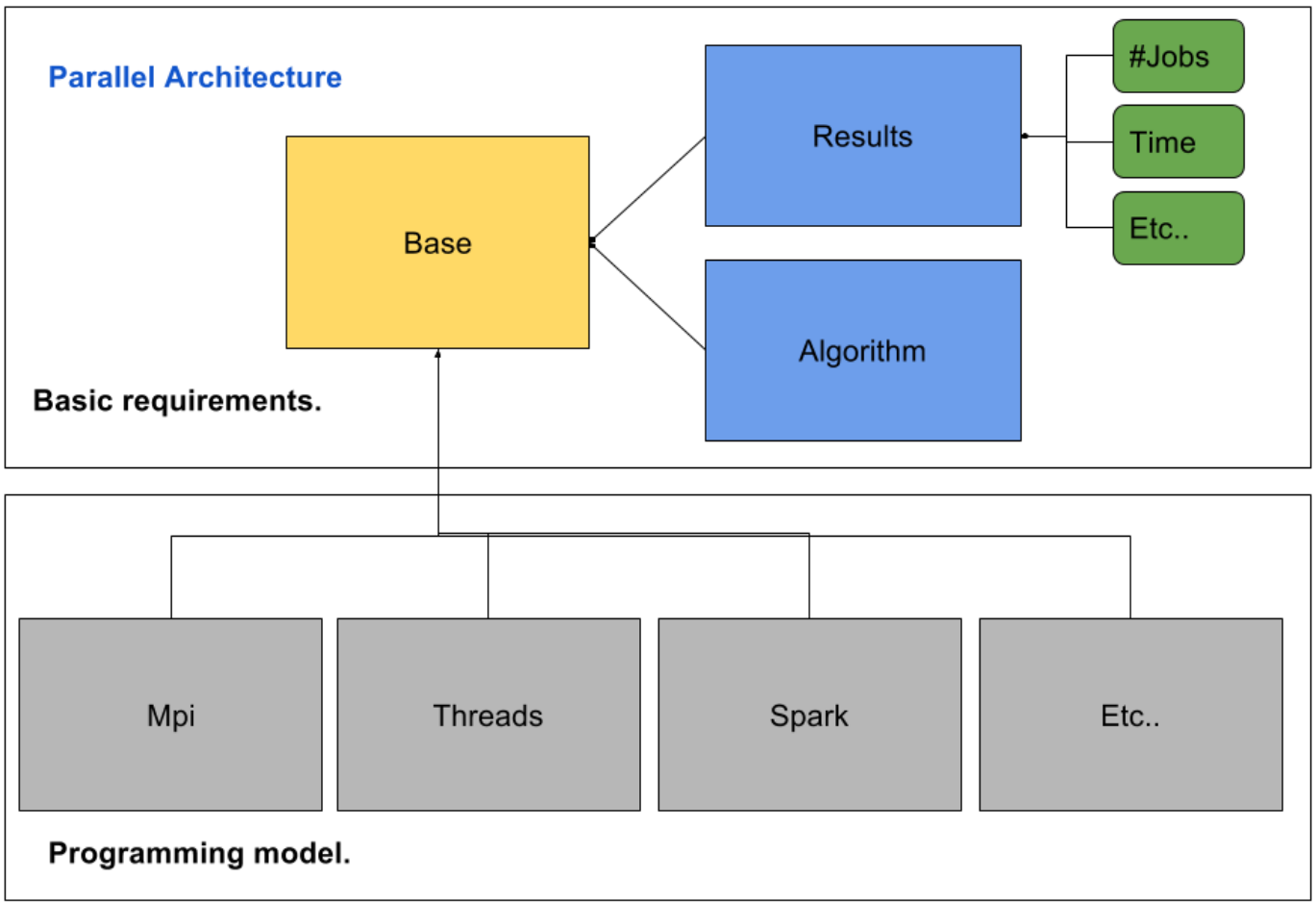
```
using namespace ROOT::Mpi;
void p2p(){
 TEnvironment env;
 TMatrixD mat;

 if(COMM_WORLD.GetRank()==0){//sending the message
  mat.ResizeTo(2,2);
  mat[0][0]=0.1;
  COMM_WORLD.Send(mat,1,0);
  cout<<"Sending matrix from process 0"<<endl;
  mat.Print();
 }else if(COMM_WORLD.GetRank()==1){//receiving the message
  COMM_WORLD.Recv(mat,0,0);
  cout<<"Receiving matrix in process 1"<<endl;
  mat.Print();
 }
}
```

Example
Peer to Peer output

```
[gerardo] [gfif] [~]$ rootmpi -np 2 p2p.C
Sending matrix from process 0
2x2 matrix is as follows
     |      0     |      1     |
-------------------------------
   0 |          0.1             0
   1 |            0             0
Receiving matrix in process 1
2x2 matrix is as follows
     |      0     |      1     |
-------------------------------
   0 |          0.1             0
   1 |            0             0
```

New parallel architecture for TMVA



Prototype with examples

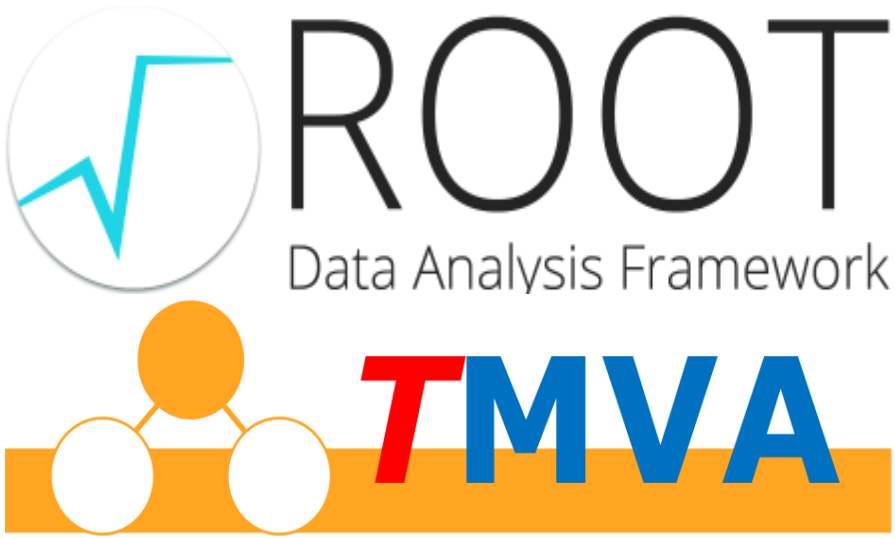
Jupyter notebooks

ParallelExecutor (MultiProc)
ParallelExecutorMpi (OpenMPI)

Conclusions

- MPI standard have all need HPC/Grid computing
  - Shared/Distributed memory
  - Checkpointing
  - Fault tolerance under development
- ROOTMpi is
  - A modern interface for MPI that uses powerful C++ design
  - A great communication system through serialization.
  - An easy way to parallelize codes in ROOT for HPC/Grid computing.
- TMVA is developing a modern architecture for multiple parallelization paradigms like HPC/Grid computing

More Information



Website

http://oproject.org

Thanks!

Questions?

Backups

- Machine Learning Software that are using MPI
  - IBM ml-toolbox link
  - Microsoft Distributed Machine Learning Toolkit link
  - Microsoft Multiverso link
  - Theano MPI link
  - eXtreme Gradient Boosting link1 link2
  - Distributed TensorFlow with MPI link
  - Intel MPI Distributed Machine Learning link