NETWORK-BASED COMPUTING LABORATORY

An Hybrid MPI/Stream Programming Model for Heterogeneous High Performance Systems

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Outline

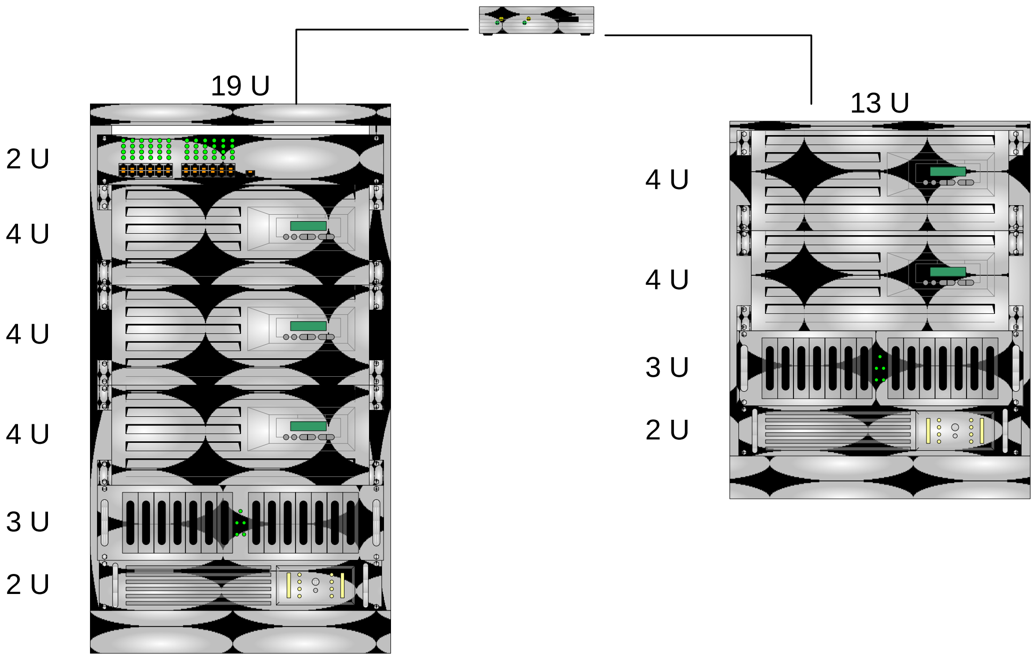
- Introduction
- The MPI , Stream and Hybrid programming models
- Architecture of the hybrid framework
- Case study: a financial application
- Conclusions

Motivation

- The increased number of nodes in modern computational systems introduces **implicit heterogeneity**:
  - For example, they can use different levels of switches
- It is difficult to use different computational cluster at the same time with the same parallel program (**clusters of clusters**)
- We want to study a way to exploit the locality in computational clusters, and in clusters of clusters

Motivation

- Two connected clusters have different latencies and bandwidths (depending on the source and the destination):
  - Inter-core
  - Inter socket
  - Level of the switch
  - Inter cluster



Motivation and problem statement

- MPI proposes a flat computational model that can well exploit the locality

- The stream models, with the light coupling between computational units: it is useful for heterogeneous networks

- This paper we study how to integrate MPI and Stream programming models in order to exploit network locality and topology

- In this paper we present a framework which integrates the two models.

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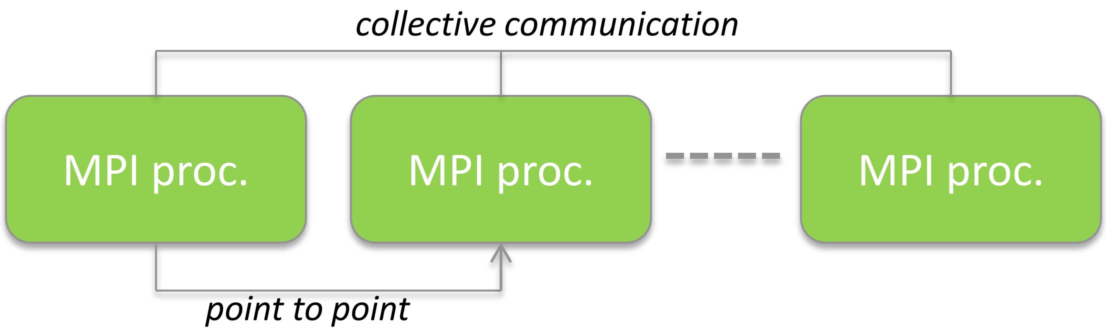
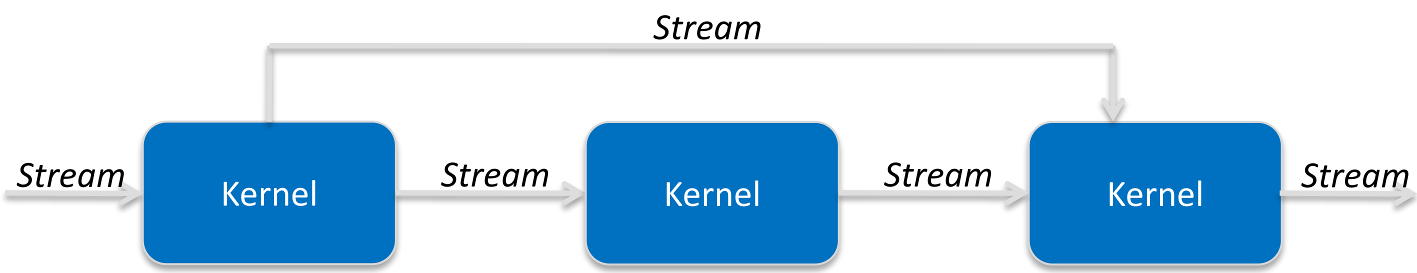
MPI and Stream models concepts



- An MPI program is a set of autonomous processes that exchange data through message passing



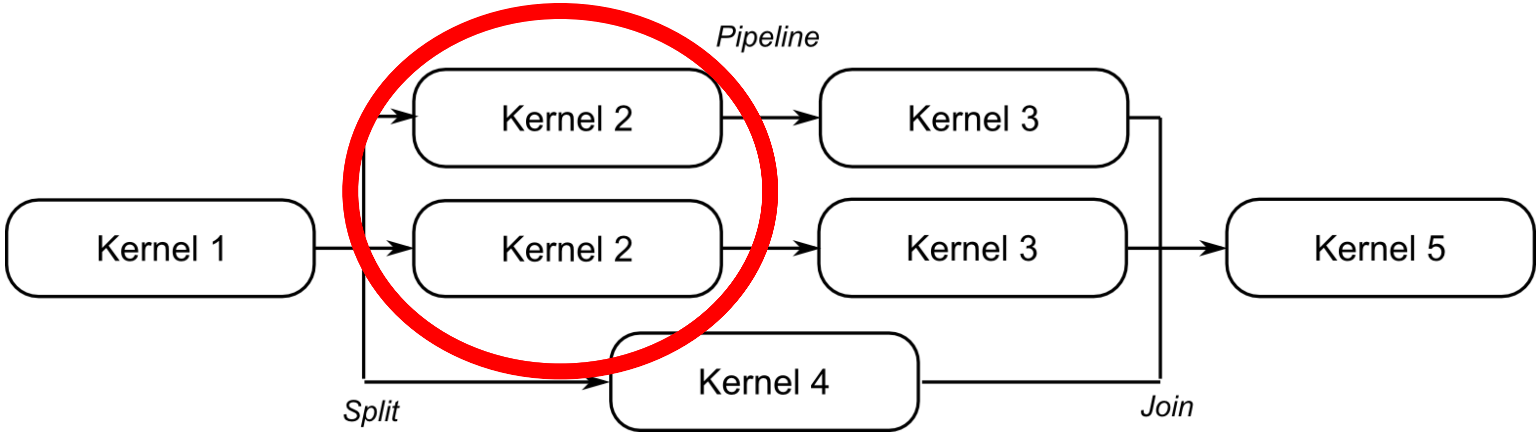
- A stream can be described as an unbounded set of data
- A series of “kernels” process each element of the stream
- The Kernel’s inputs and outputs are streams

Stream model

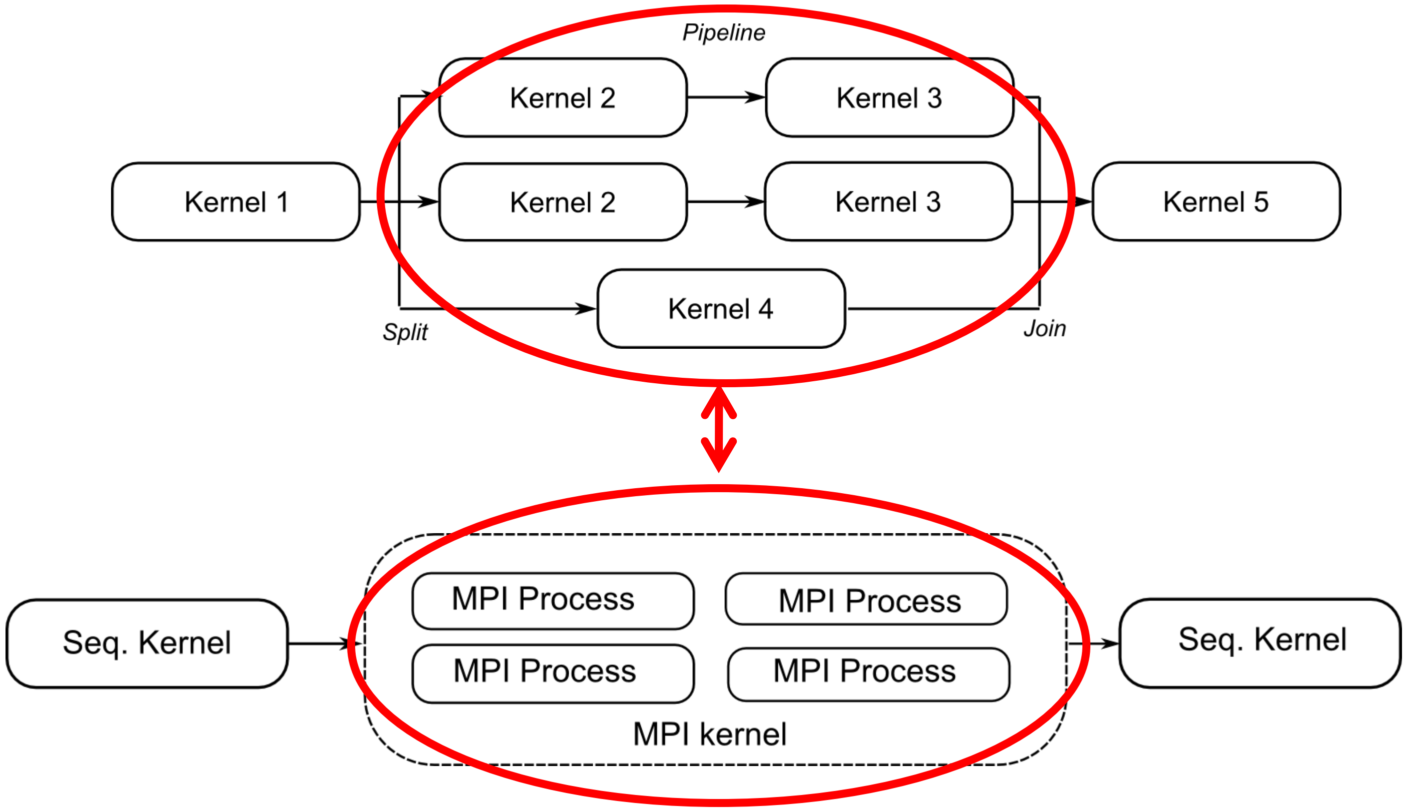
- The data model is modeled as **transient data streams** (not persistent relations)

- They arrive continuously in **unpredictable** way, and in **unbound streams**

Siblings -> MPI application



The hybrid model



- In the hybrid model a subset of kernels can be mapped on a set of MPI processes;
- Or, from another point of view, a set of MPI processes can be transformed as a stream kernel.

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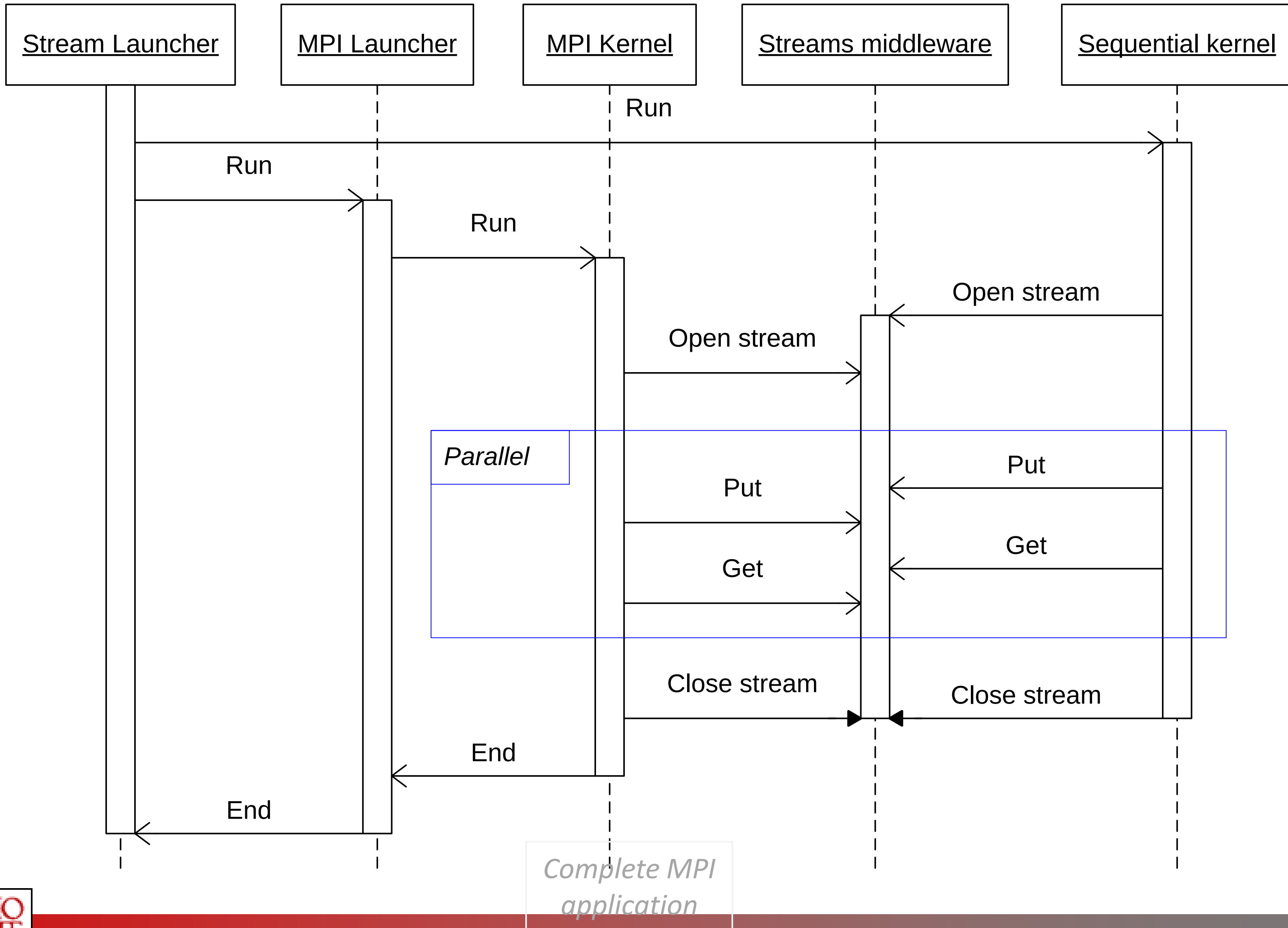
The launching process

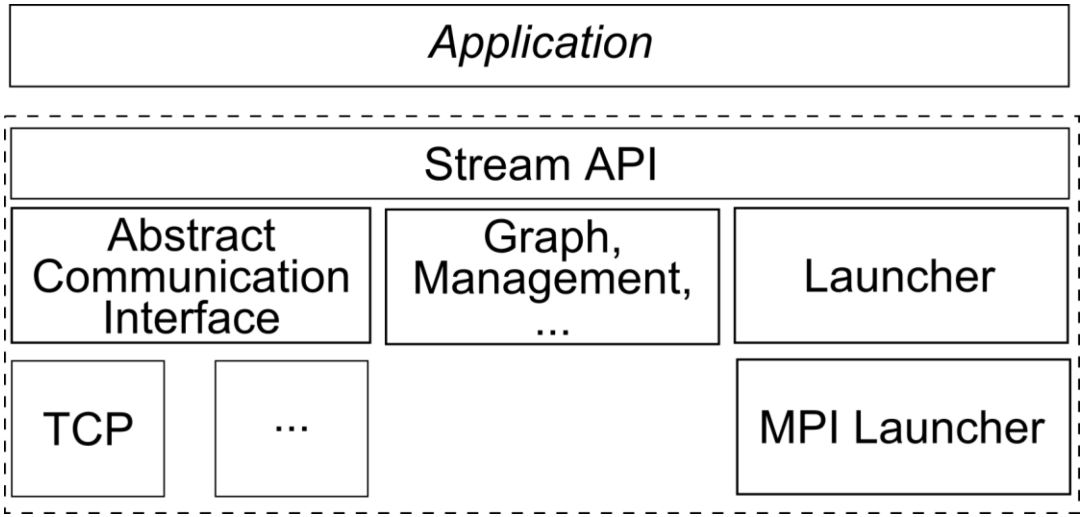
- The launcher requires a description of the whole system, and synchronization of MPI and sequential kernels in different nodes
- An XML file describes the task graph
- From the XML file the launcher dynamically produces MPI hostfiles and startup scripts
- At launch time, every kernel registers itself with the middleware or polls the stream autonomously

The hybrid framework sequence diagram



The hybrid framework architecture

- The launcher starts both stream kernels and MPI applications
- The core is a modularized communication API



- A common interface allows to interact with different underlying protocols
- The graph management module builds a view of the application tasks

A simple example

The main function registers the kernels, and starts the streams

```
int main (...) {
  osf_KernelContext_t *kctx;
  osf_Init(...);
  osf_RegisterKernel(0, OSF_KRNTYP_POLLING,
              OSF_KRN_STATELESS, SourceKernel, &kctx);
  osf_RegisterKernel(1, OSF_KRNTYP_POLLING,
              OSF_KRN_STATELESS, FilterKernel, &kctx);
  osf_StartStreams();
  osf_Finalize();
}
```

A simple example

A source kernel puts new data into a stream:

```
osf_Result_t SourceKernel(osf_KernelContext_t *ctx) {
  static osf_Stream_t *s = NULL;
  if (s==NULL)
    osf_Open(&s, OSF_STR_OUT, 1);
  ...
  record = sin(t)+sin(4+2*t);
  osf_Put(s, &record, sizeof(record) );
  return OSF_ERR_SUCCESS;
}
```

A simple example

A filter kernel gets the data from a stream, elaborates them, and eventually, puts them in another stream

```
osf_Result_t FilterKernel(osf_KernelContext_t *ctx) {
  static osf_Stream_t *sIn = NULL;
  if (sIn==NULL)
    osf_Open(&sIn, OSF_STR_INPUT, 0);
  ...
  res = osf_Get( sIn, &x, sizeof(double), &receiv );
  return OSF_ERR_SUCCESS;
}
```

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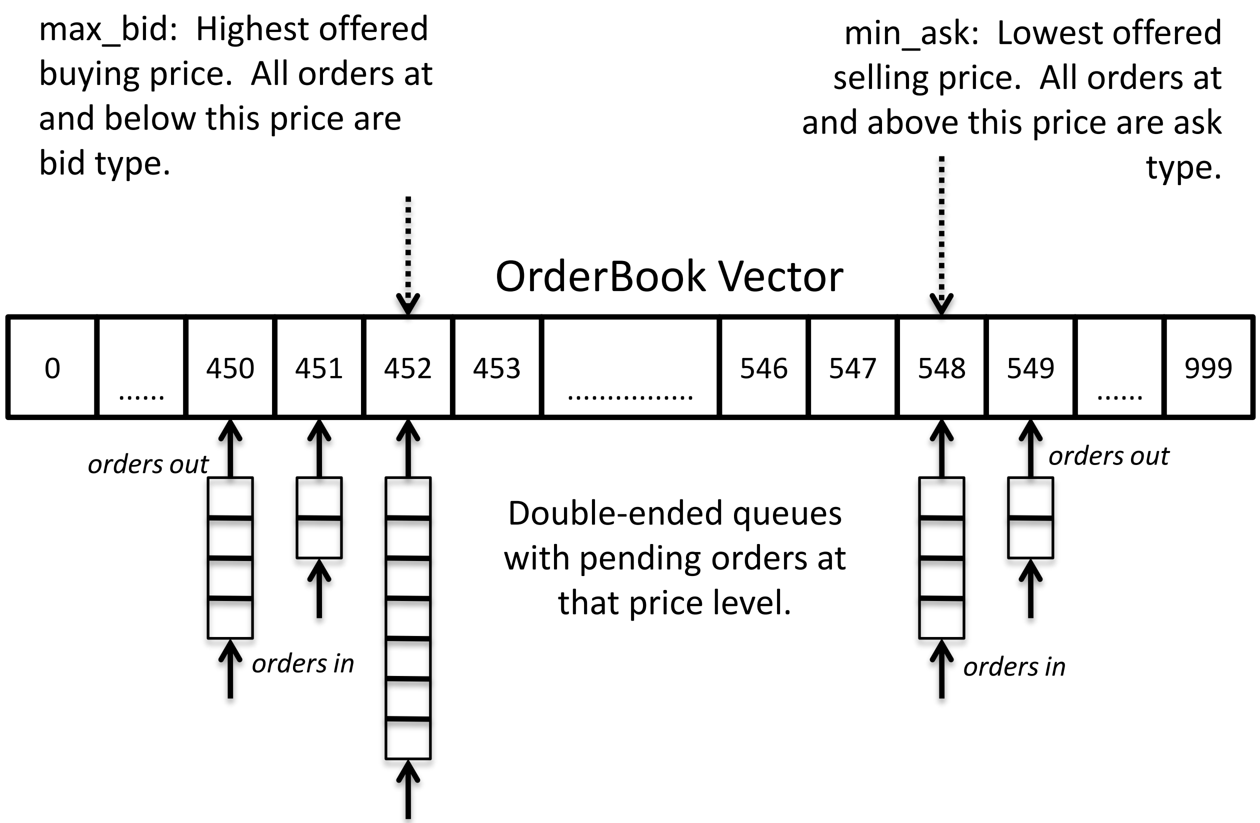
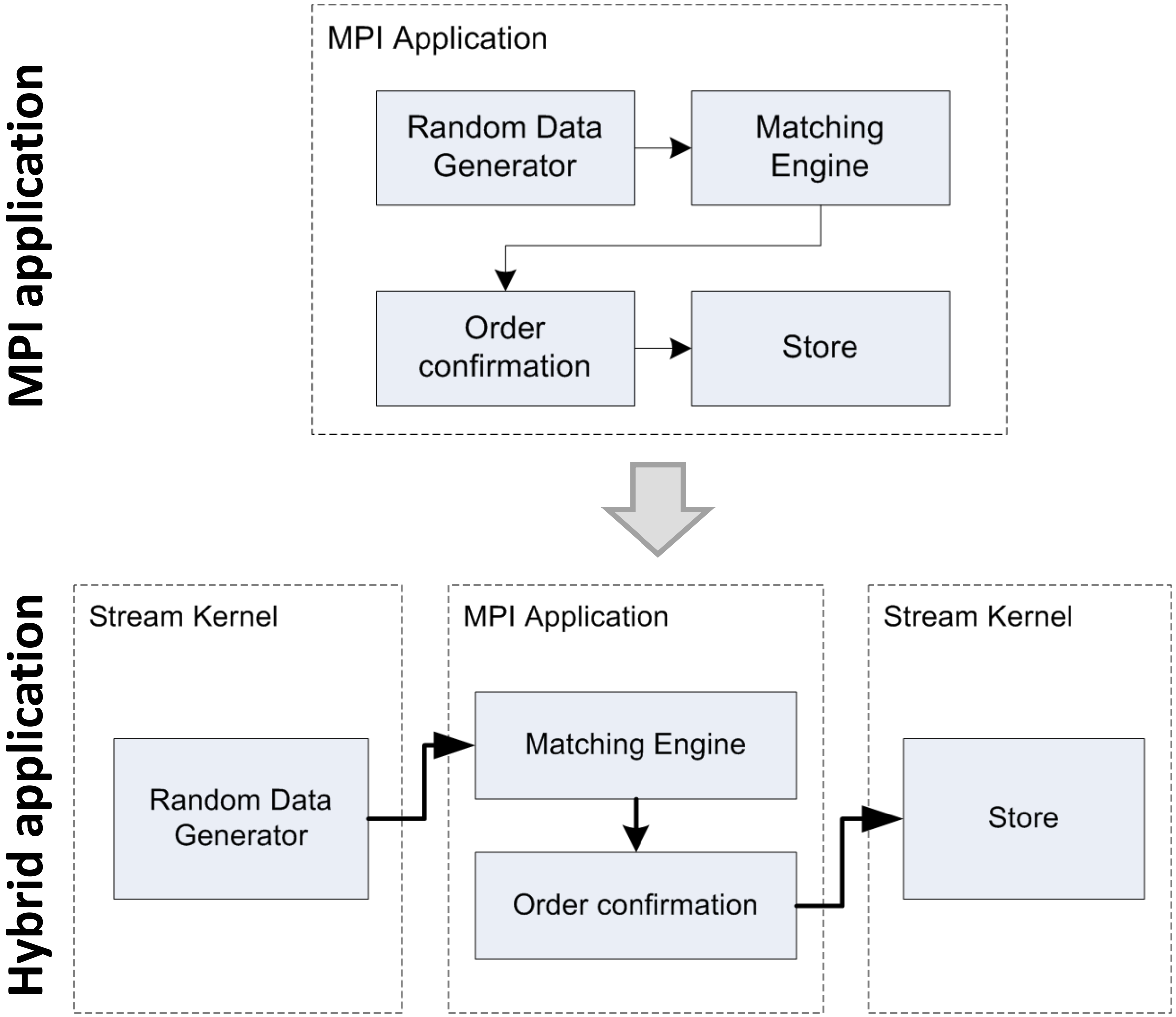
Case study: a financial simulation application

- The application simulates a stock
- It generates random orders
- A matching engine compares offers, bids and quantities
- When it elaborates an order, it sends a confirmation

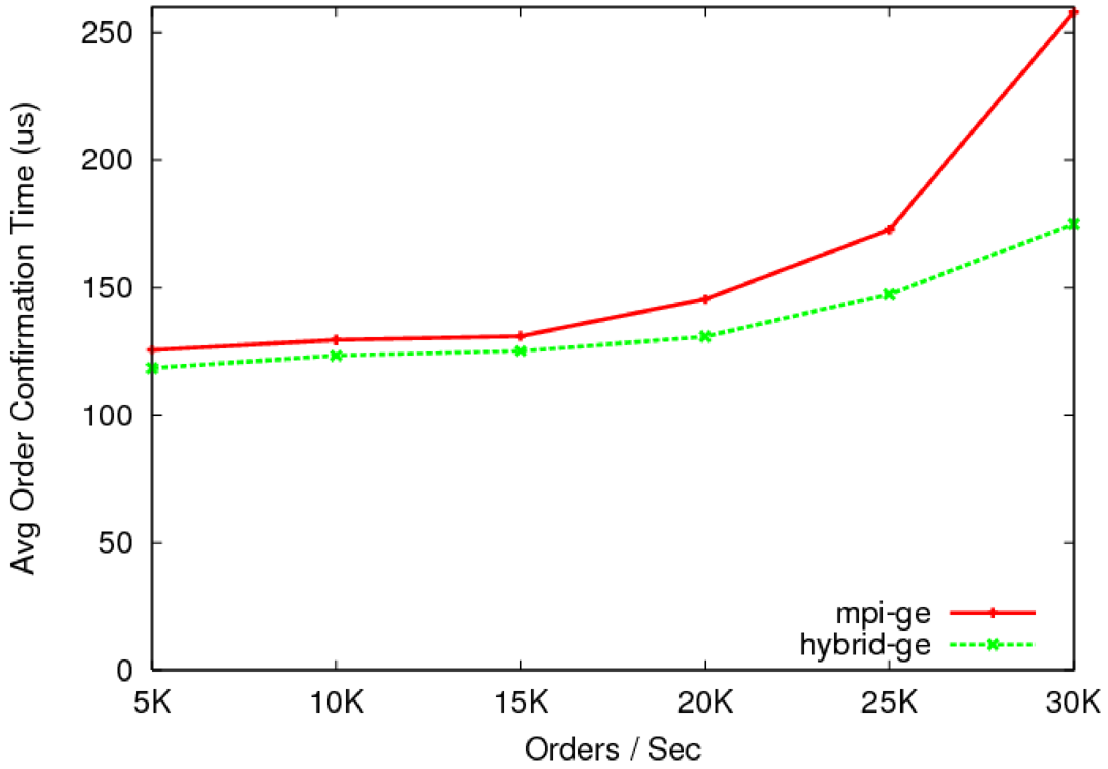


Case study: a financial simulation application



- The application has 4 tasks
- The hybrid version uses both MPI and Stream primitive to communicate
- The stream kernels are not synchronized with one another

Case study: a financial simulation application



- The experiment was lead on a single cluster
- The hybrid version shows a better execution time
- The improvement varies from 5% to 32% (simulating 30,000 orders/s)

Conclusions and future directions

- We proposed a way to exploit the locality using a hybrid Stream/MPI programming model
- We presented the prototype of a hybrid framework, and validated it using a financial simulation
- We plan to experiment this approach using clusters of clusters
- We plan to integrate the framework in the message queue of MPI middlewares

Thank you

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