Automatic MPI Application Transformation with ASPhALT

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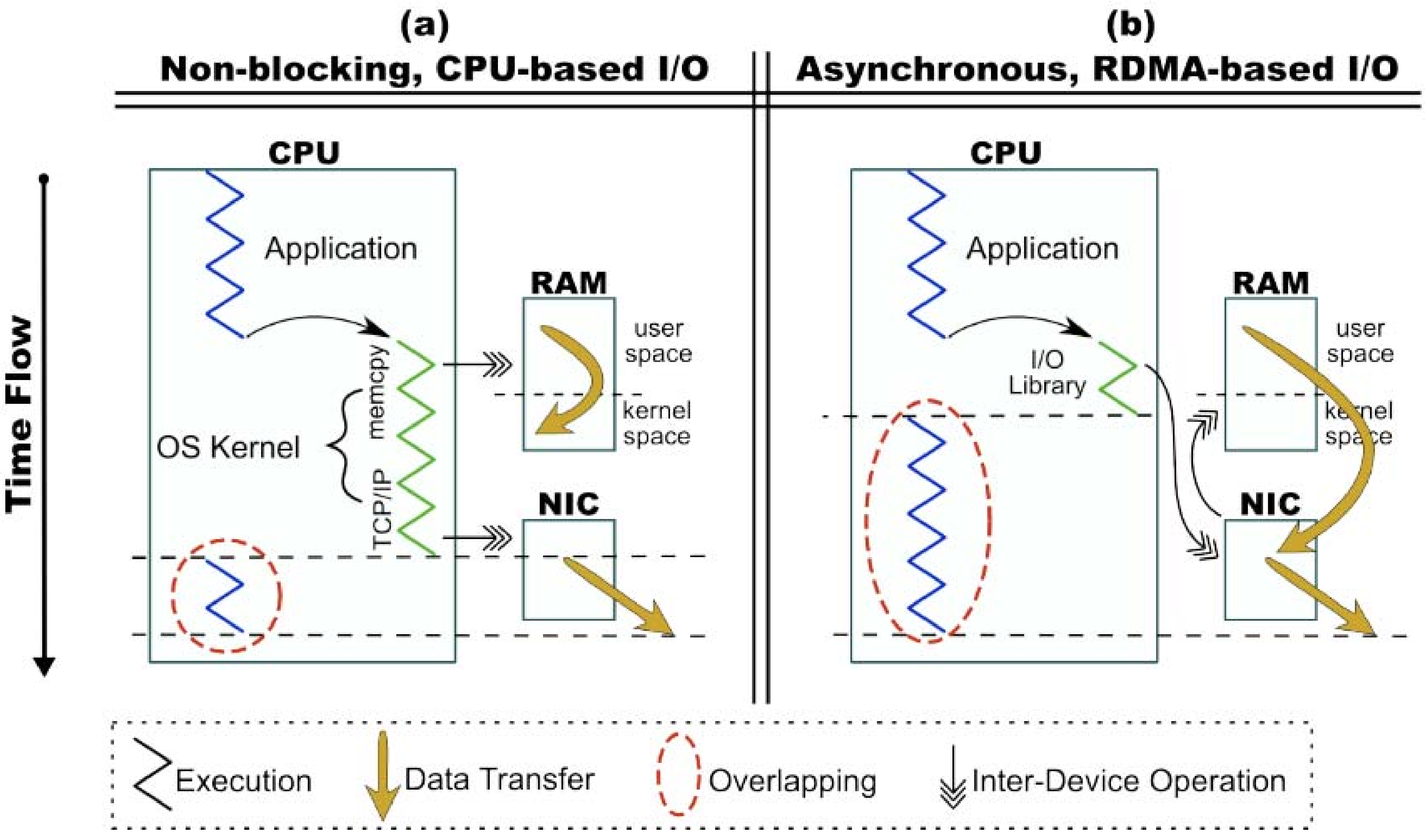
Overview

- Goal
  - High performance communication for MPI applications that is easy to achieve
- Solution
  - An automatic system that transforms simple communication code into more efficient code by improving the overlap of computation with communication
- Impact
  - Existing applications can enjoy improved performance
  - New applications can be written more simply and automatically optimized for various platforms

Overlapping Computation and Communication



Overlapping Details

- Minimize effective overhead of data movement by overlapping it with useful work
  - An old idea
  - Different approach than using large messages for high bandwidth
- What does it mean for parallel application development?
  - Post a send as soon as sufficient data is ready
  - Do useful work
  - Check status after completion (minimal polling or sleeping)
- Difficult to optimize, difficult to maintain
  - Particularly as platforms change

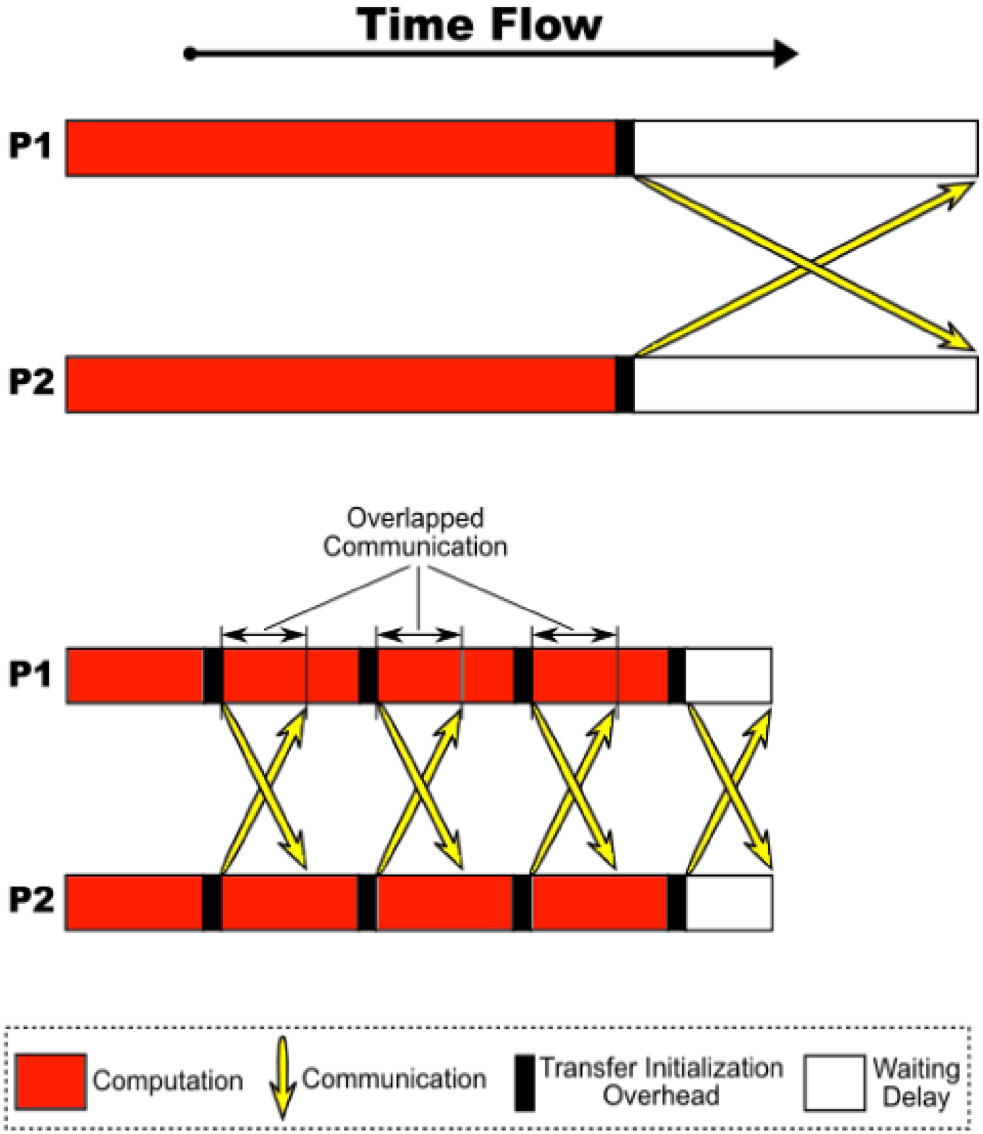
Overlapping Transformation - Simple Example

Original code

```
integer, dimension(M,N):: array

do i = 1, N
   /* computation kernel */
   subroutine( array(1,i) )
enddo

size = M*N
DataTransferCall( array(1,1), size, ... )

Other_Computation()
```

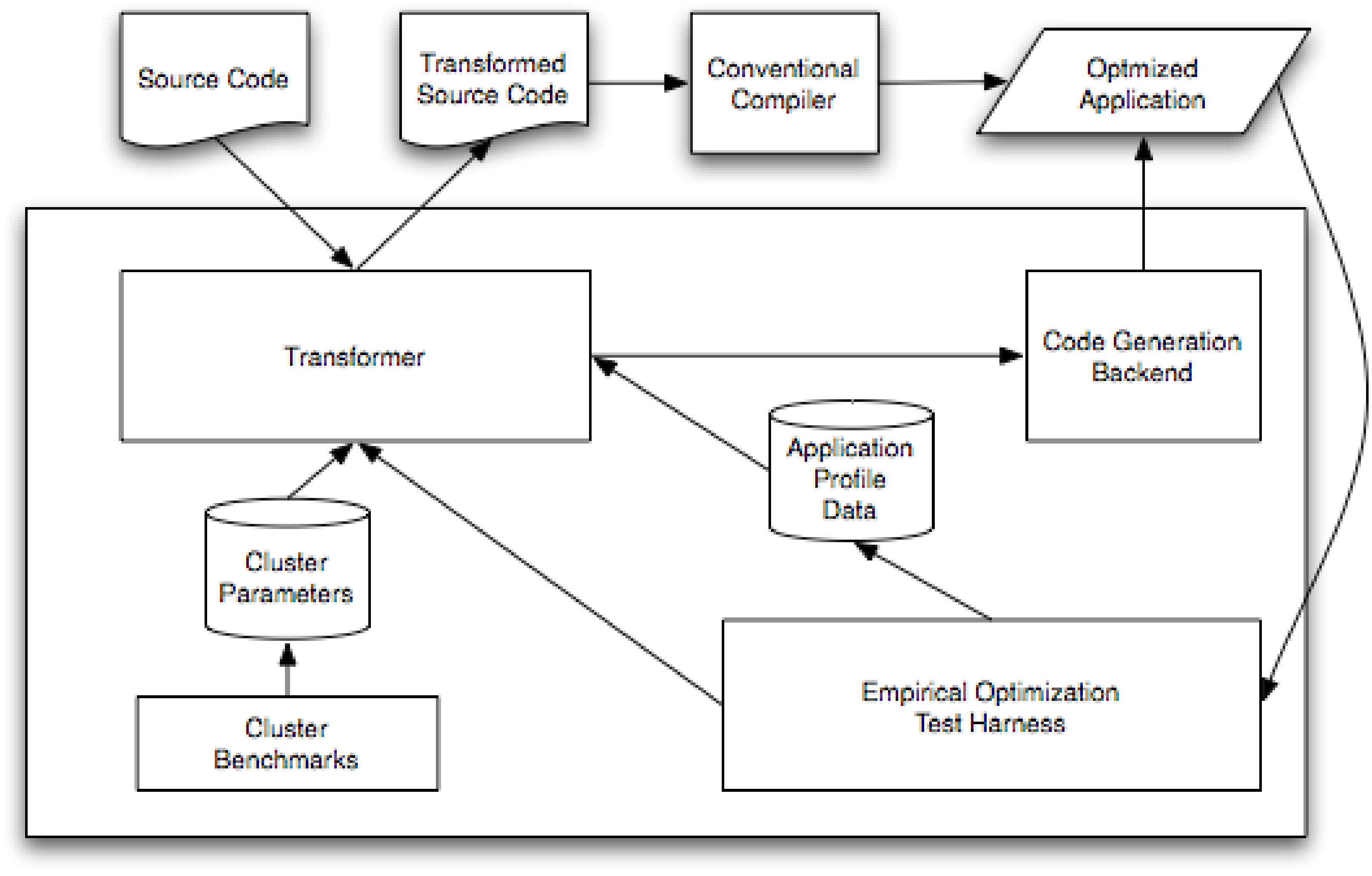
Tiled code

```
integer, dimension(M,N):: array

do i = 1, N, K

   do j = i, i+K-1
      /* computation kernel */
      subroutine( array(1,j) )
   enddo
   if( i > K ) then
      /* block for the arrival of the data  */
      MPI_WAITALL( request( i - K) )
   endif

   size = M*K
   /* asynchronous network transfer */
   MPI_ISEND( array(1,i), size, ... )
   MPI_IRECV( destn(...), request(i), ... )
enddo

MPI_WAITALL( request( i - K) )
```



ASPhALT

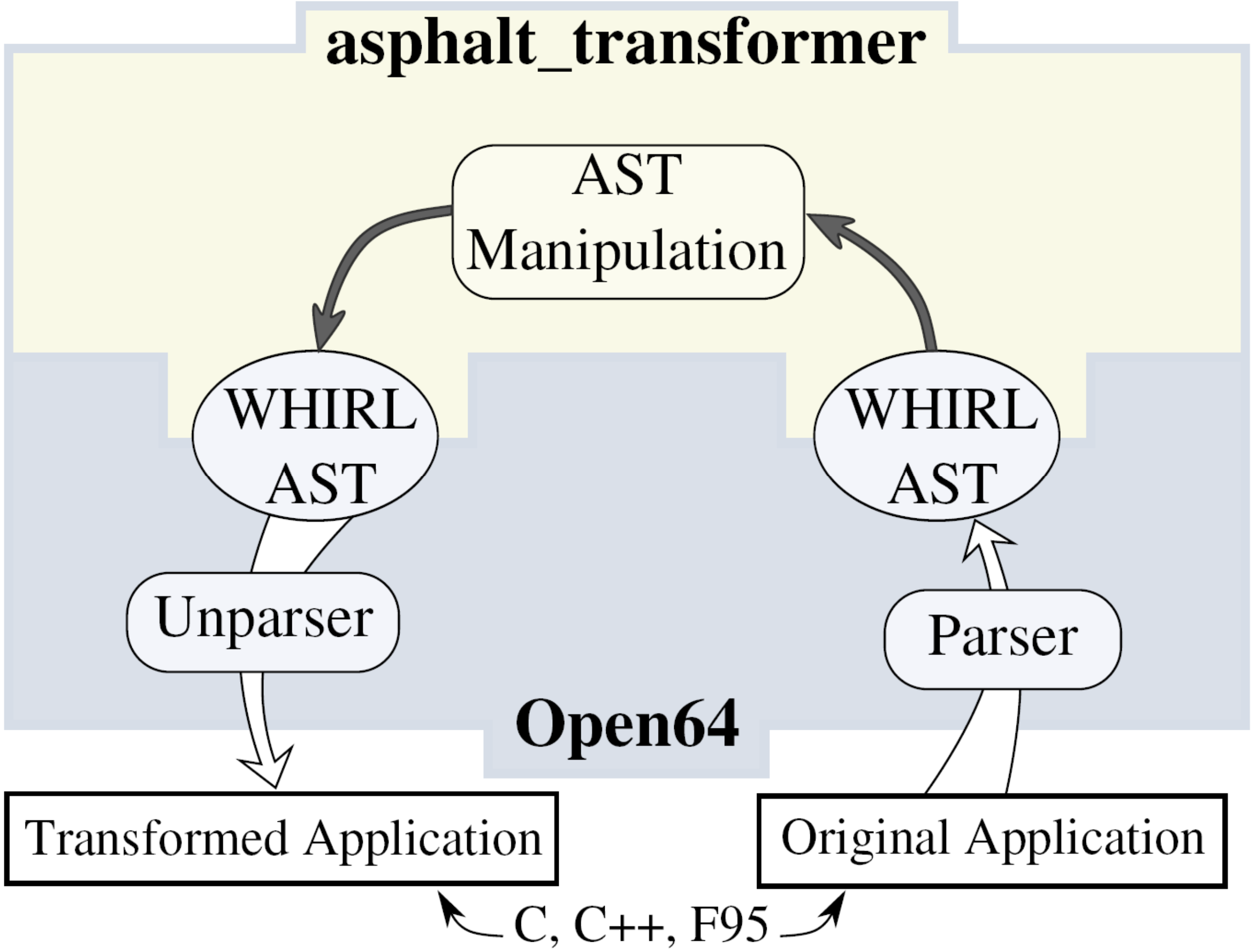
- **A**utomatic **S**ystem for **P**arallel **A**pp**L**ication **T**ransformation



ASPhALT Framework

- Based on the Open64 compiler
  - Early work was based on Nestor and was Fortran77-only (Parco ‘05)
- Open64 uses intermediate representation known as WHIRL
  - WHIRL has 5 levels and the compiler works by progressively lowering from the highest to the lowest
- A WHIRL tree can be transformed and unparsed to high-level source code
  - At the highest two levels

Transformer Structure

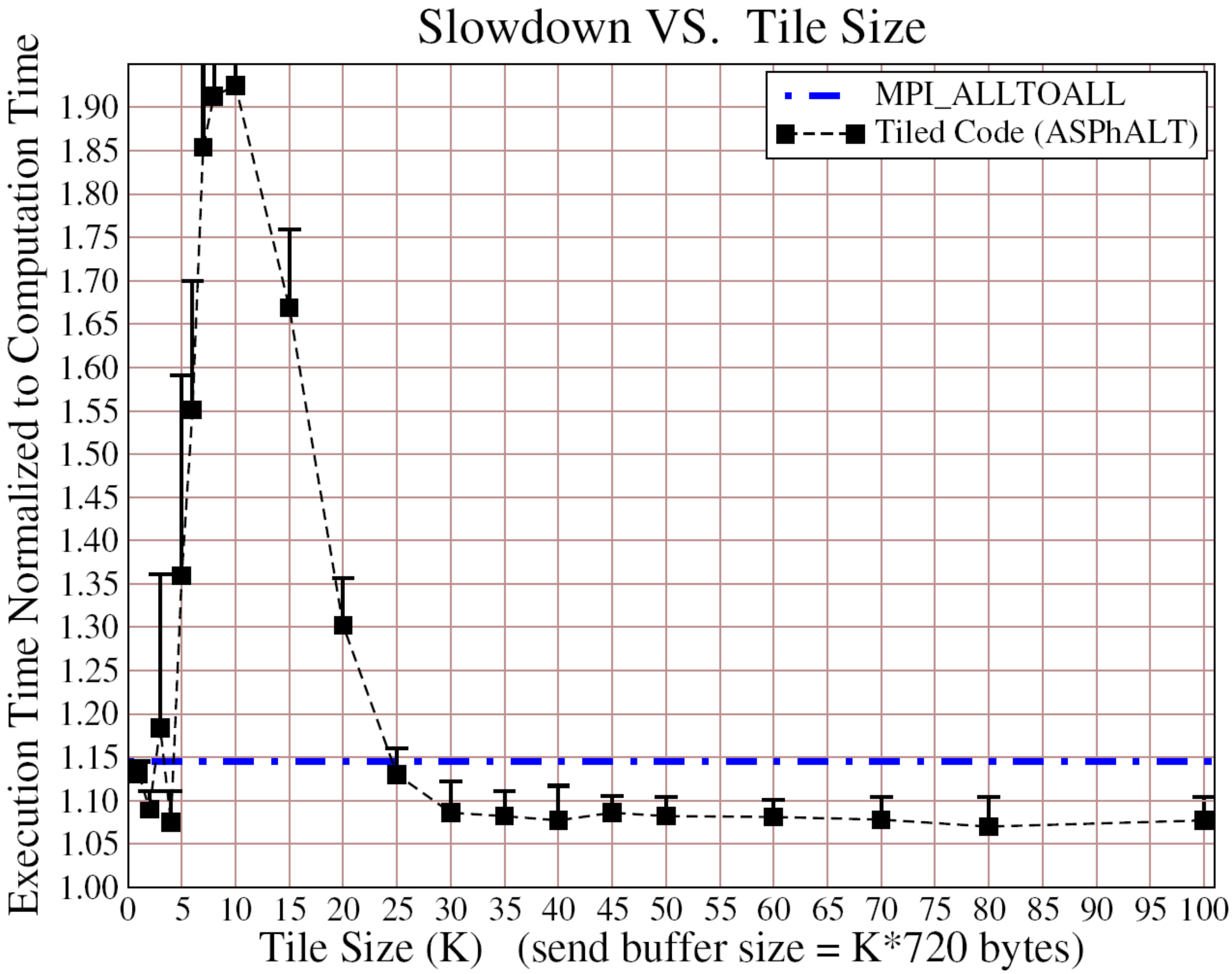


Evaluation of Transformations

- Initial manual transformations to evaluate efficacy
  - A. Danalis, K. Kim, L. Pollock, M. Swany, "Transformations to Parallel Codes for Communication-Computation Overlap", SC05
- Two scientific applications as targets
  - Chem E. and Physics apps from UD
  - FFTW and MPI_ALLTOALL
- Created communicationless versions of the code
  - Normalized execution time

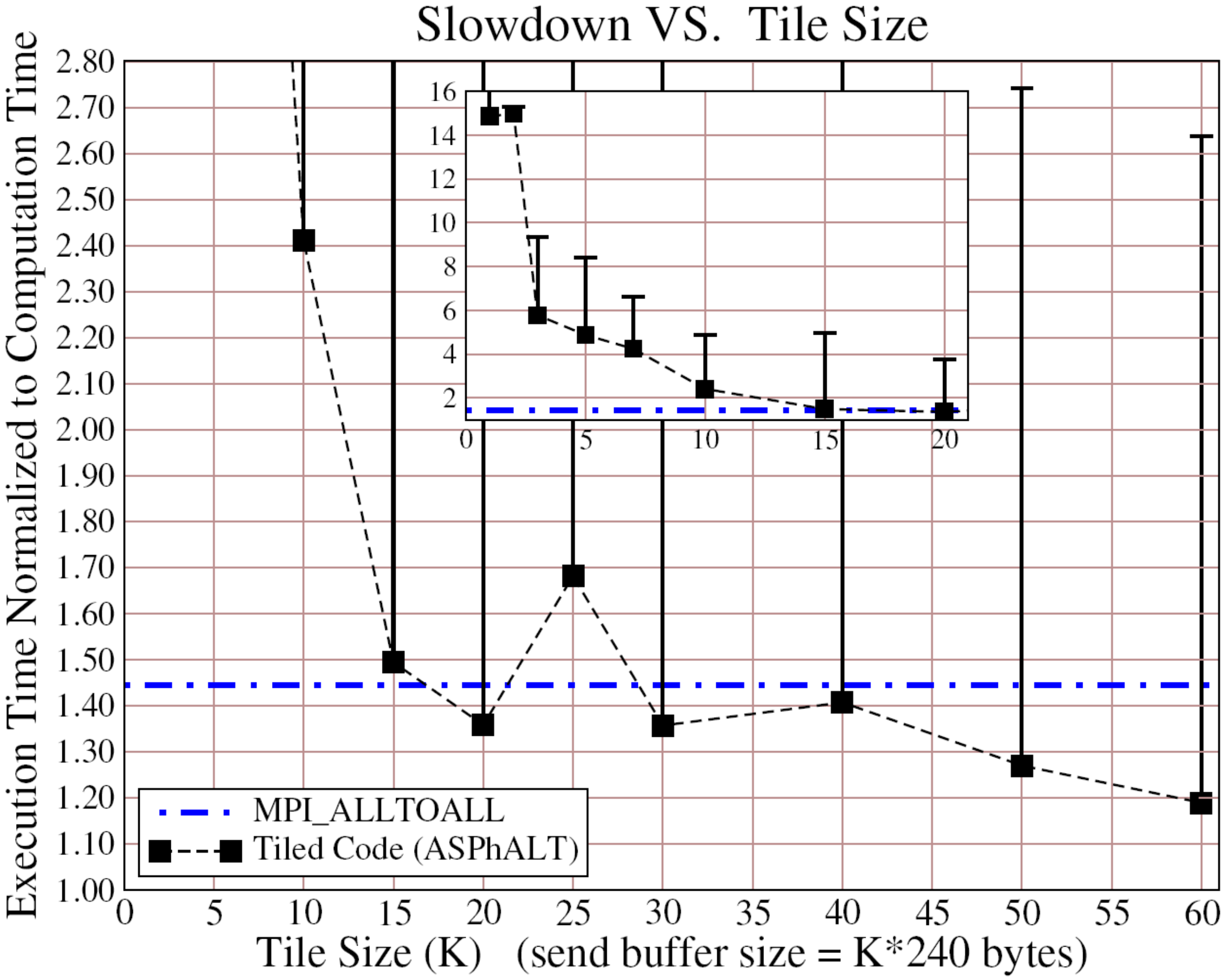
$$\frac{ExperimentRuntime}{CommunicationlessRuntime}$$

Evaluation of Automatic Transformation - Synthetic Kernel



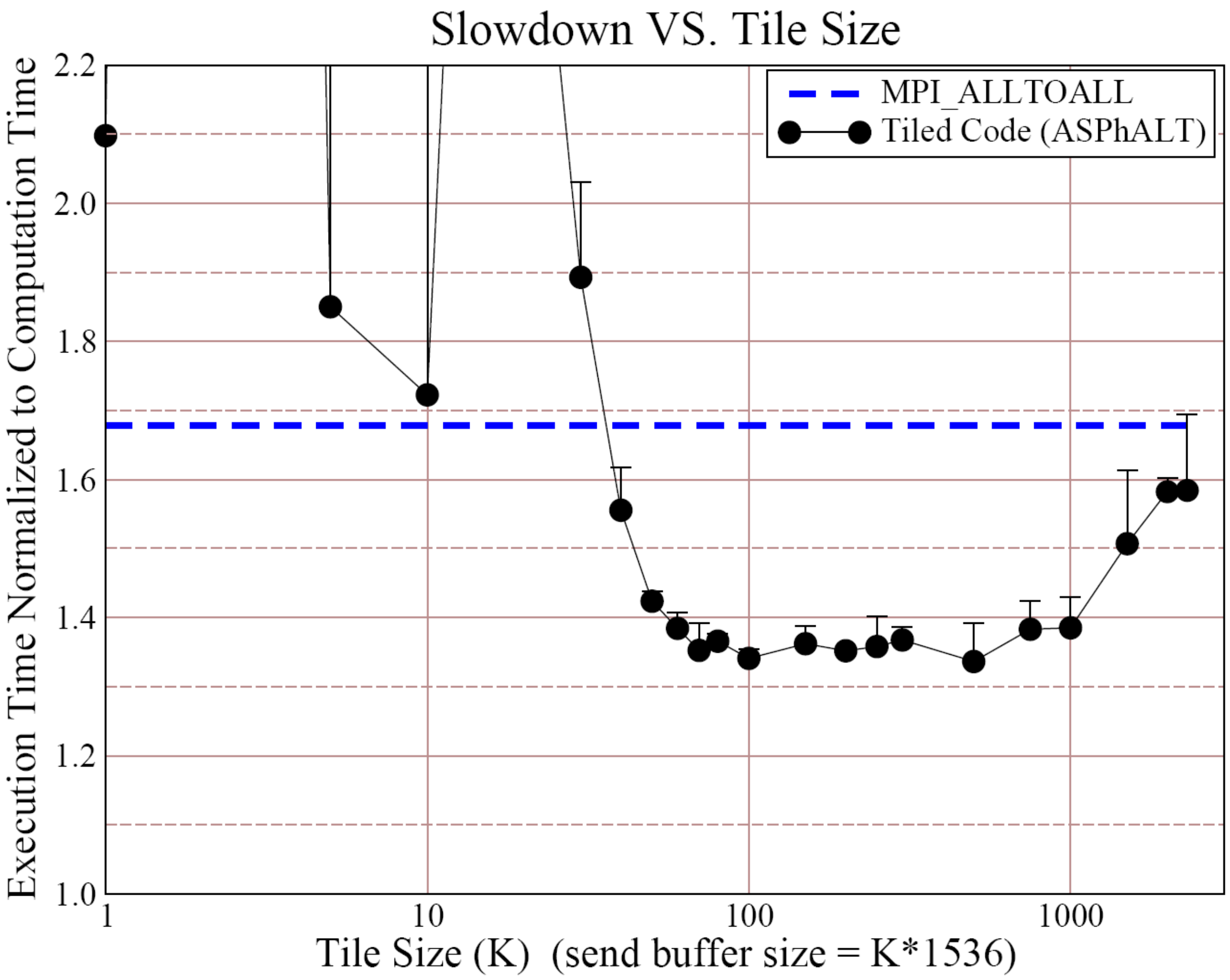
interconnect:**Ammasso**, NP:**16**, size:**1440x1440x48x16** Bytes

Evaluation of Automatic Transformation - Synthetic Kernel



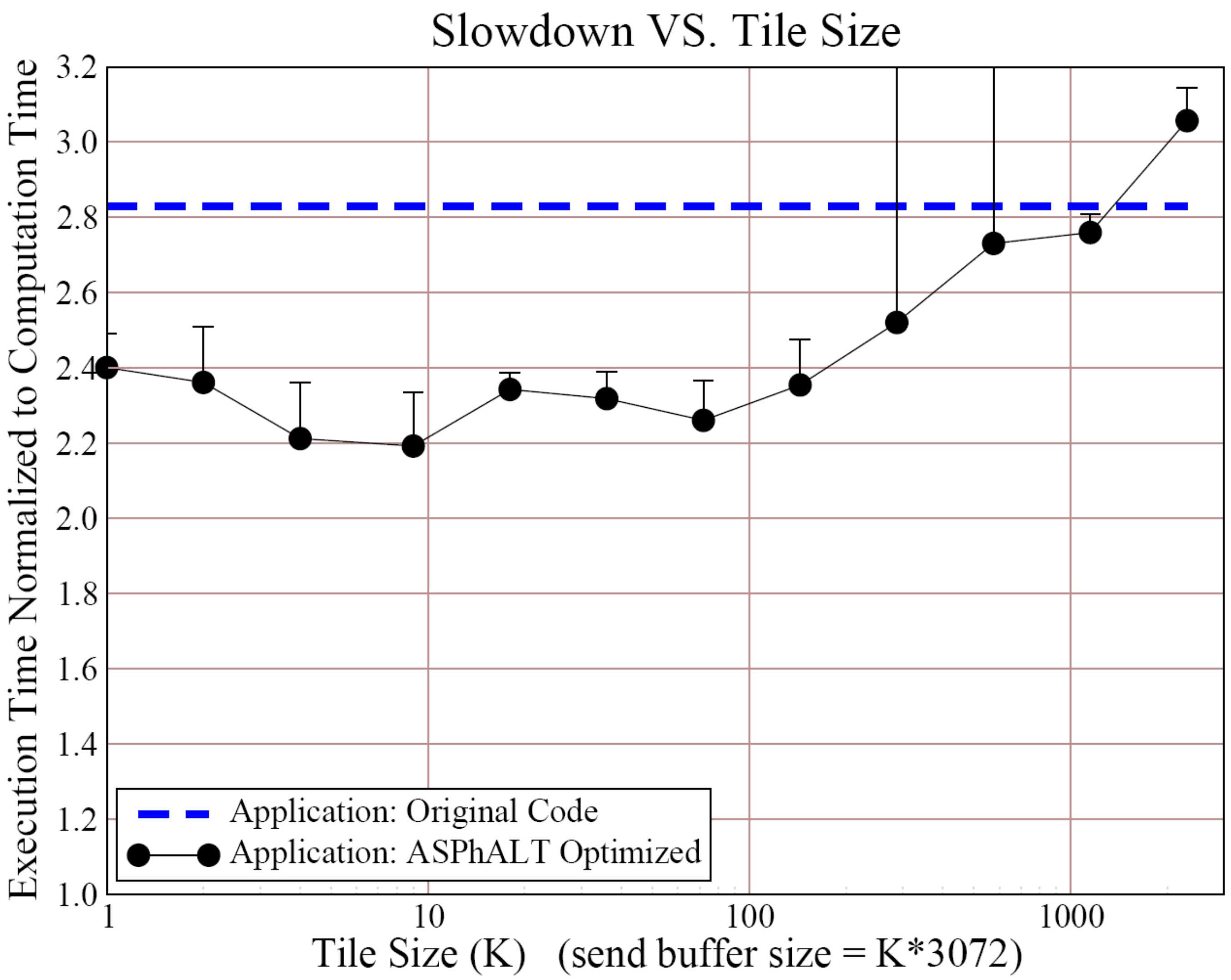
interconnect:**Myrinet-MX**, NP:**48**, size:**1440x1440x48x16** Bytes

Evaluation of Automatic Transformation - Application “visco”



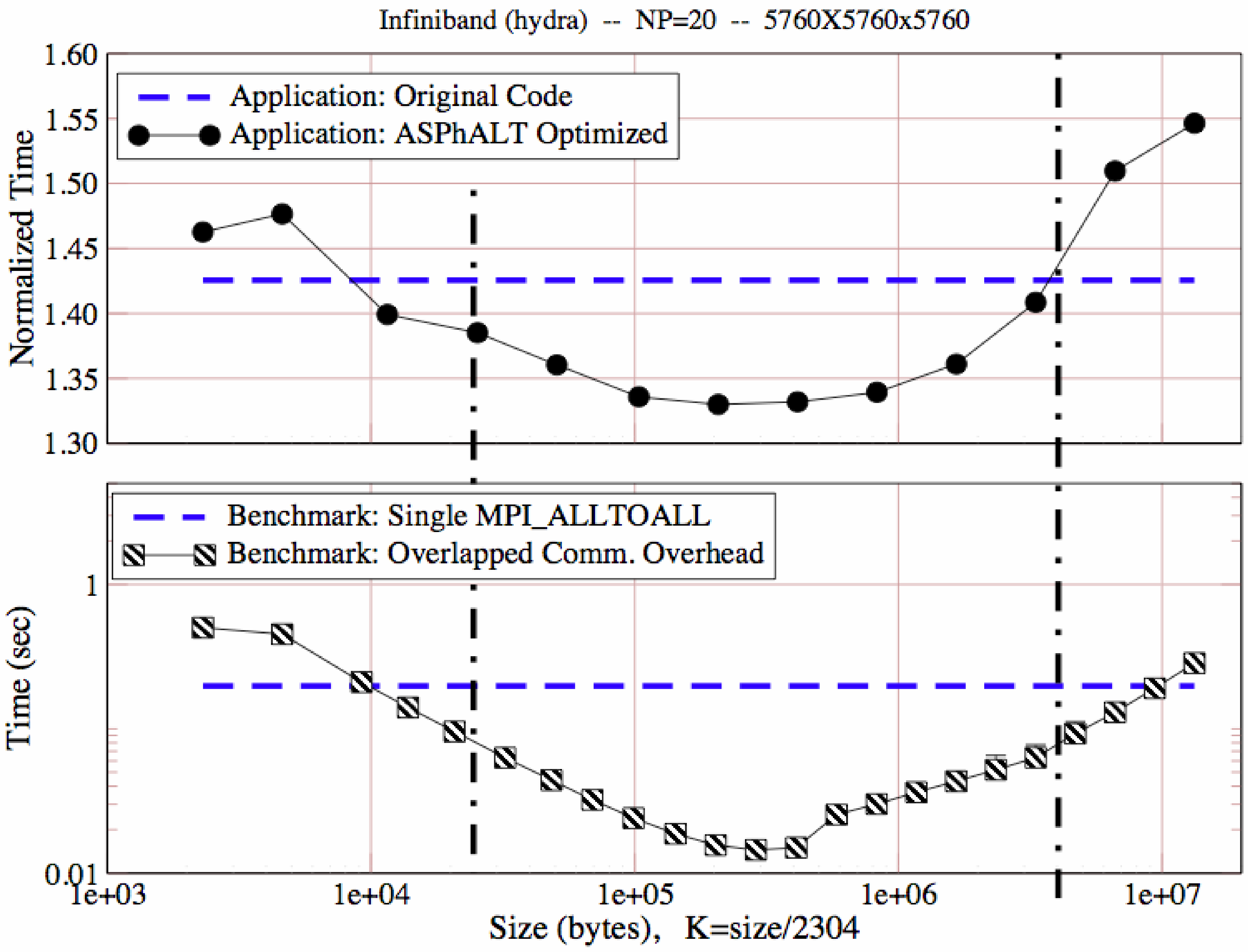
interconnect:**Myrinet-MX**, NP:**48**, size:**9216x2305x48x16** Bytes

Evaluation of Automatic Transformation - Application “visco”

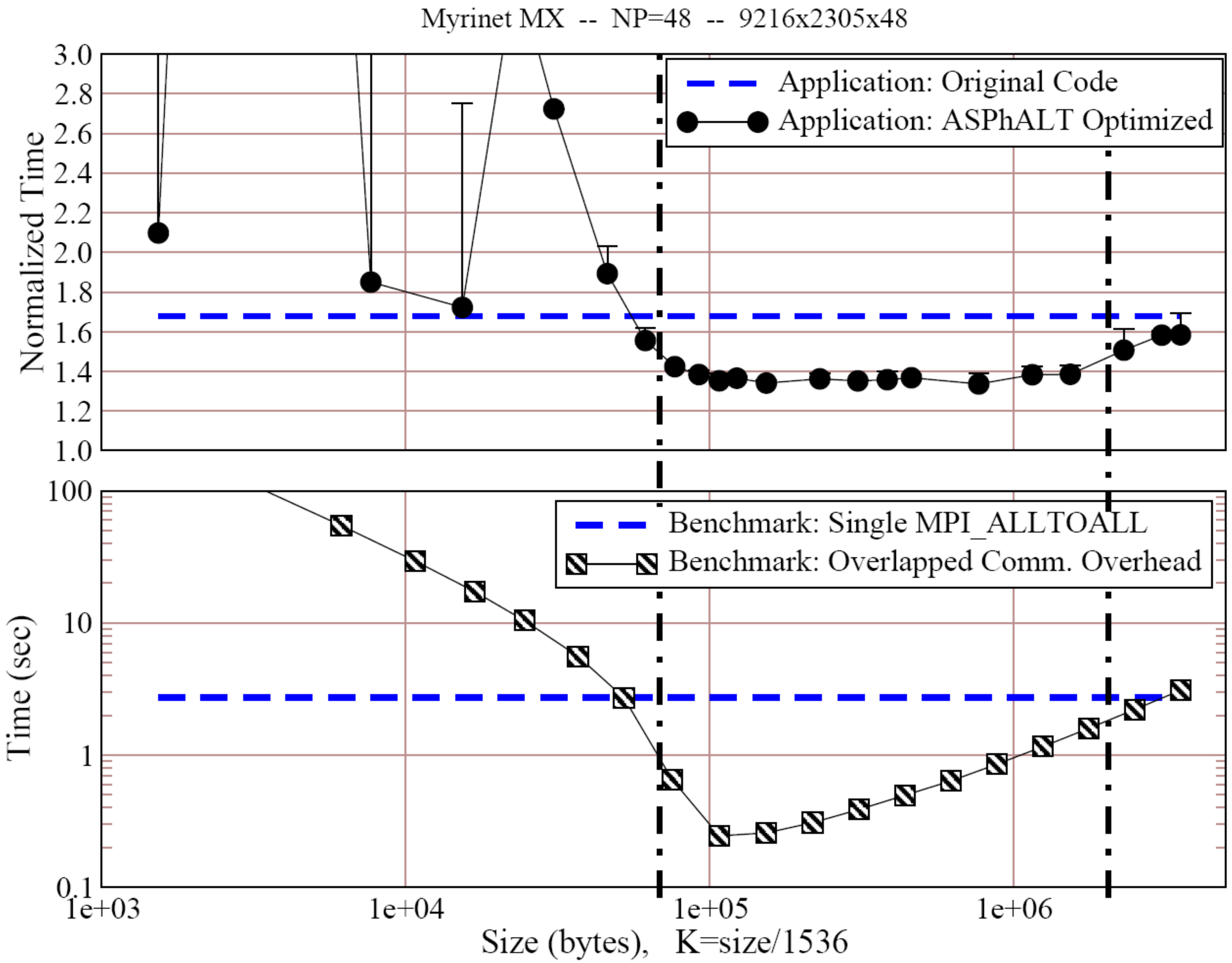


interconnect:**Myrinet-GM**,   NP:**24**,   size:**9216x2305x48x16** Bytes

Svstem Benchmarks



System Benchmarks



Ongoining Efforts

- Apply technique to Scatter/Gather (C)
- Apply technique to large send “fission” (C)
  - Matching sends/recvs impossible without out of band information
- Use OpenFabrics APIs
  - DAPL
- Support for compilation of communication into lower-level routines
  - Abstract hardware details
  - Abstract protocol/library details
  - Abstract language issues (Fortran and pointers)

Acknowledgements

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  - ASPhALT: Anthony Danalis, Aaron Brown, Andrew Gearheart, Magnus Johnsson
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- ASPhALT co-PI: Lori Pollock

Questions?