Message Passing Interface

In Java for AgentTeamwork (MPJ)

By Zhiji Huang

Advisor:

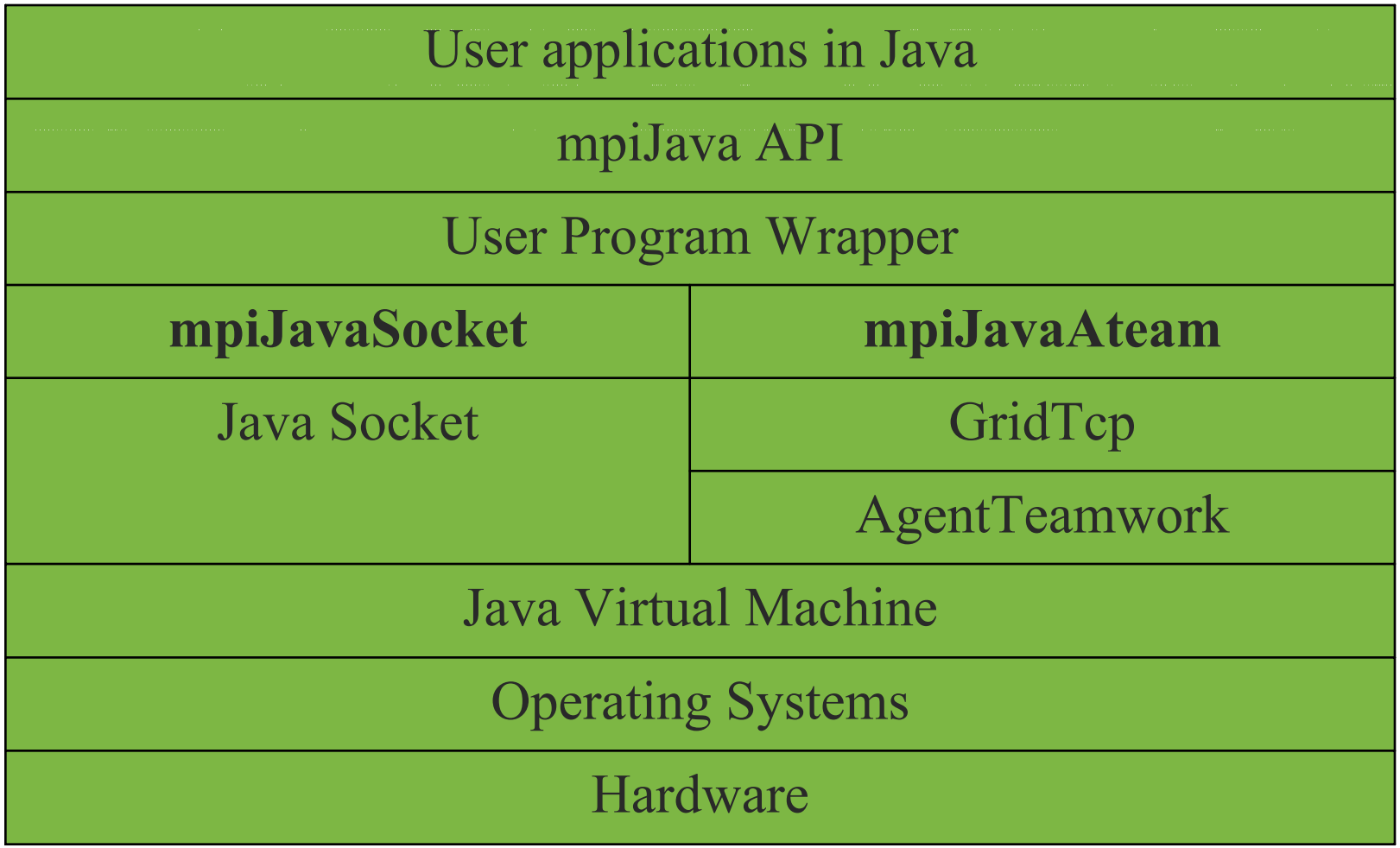
Professor Munehiro Fukuda

2005

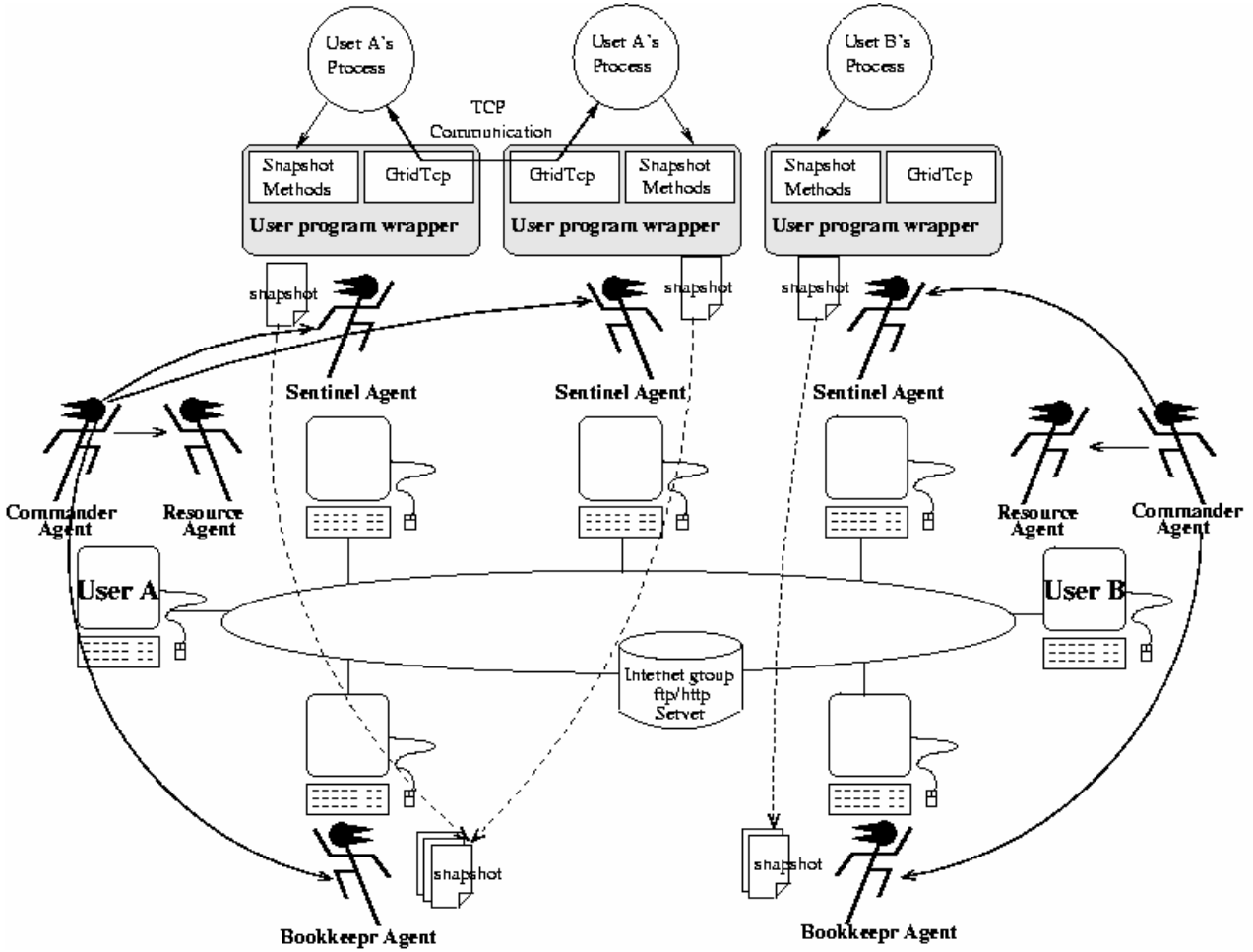
AgentTeamwork

- User requests AgentTeamwork for some computing nodes.
- AgentTeamworking manages the resources for performance and fault tolerance automatically.

AgentTeamwork Layers



AgentTeamwork



GridTCP

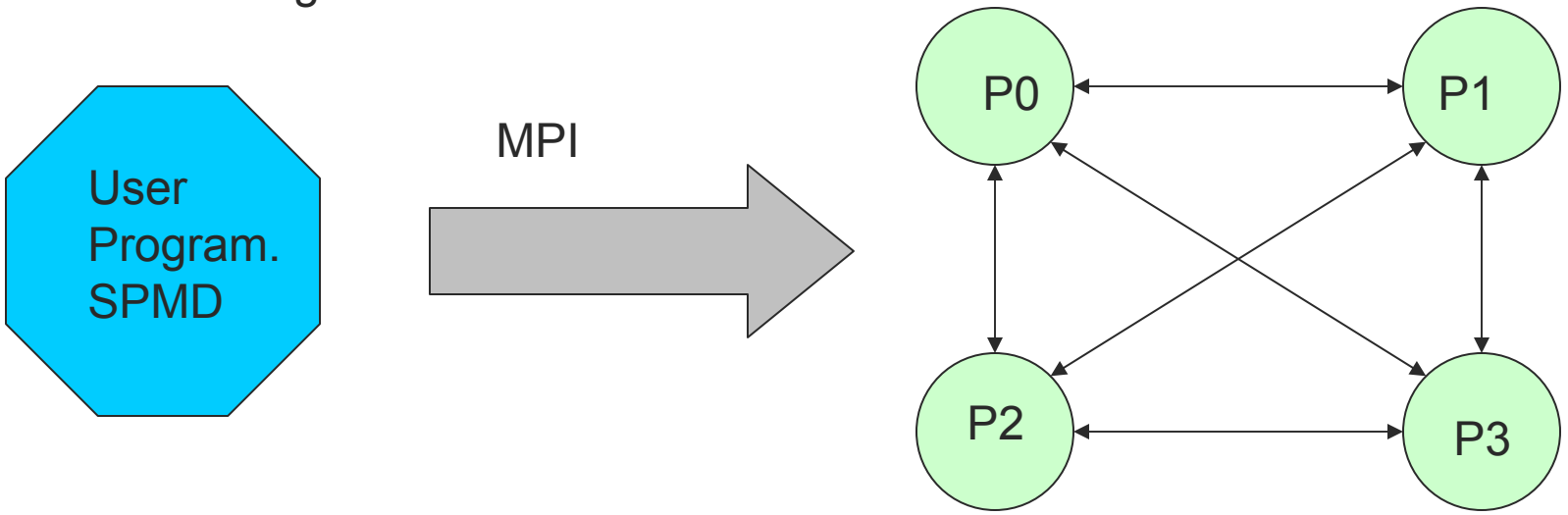
- Extends TCP by adding message saving and check-pointing features.
- Automatically saves messages.
- Provides check-pointing, or snapshots of program execution.
- Ultimately allows programs to recover from errors.
  - Node crashes, etc.

GridTcp

```
public class MyApplication {
  public GridIpEntry ipEntry[];              // used by the GridTcp socket library
  public int funcId;                         // used by the user program wrapper
  public GridTcp tcp;                        // the GridTcp error-recoverable socket
  public int nprocess;                       // #processors
  public int myRank;                         // processor id ( or mpi rank)
  public int func_0( String args[] ) {       // constructor
    MPJ.Init( args, ipEntry, tcp );          // invoke mpiJava-A
    .....;                                   // more statements to be inserted
    return 1;                                // calls func_1( )
  }
  public int func_1( ) {                     // called from func_0
    if ( MPJ.COMM_WORLD.Rank( ) == 0 )
      MPJ.COMM_WORLD.Send( ... );
    else
      MPJ.COMM_WORLD.Recv( ... );
    .....;                                   // more statements to be inserted
    return 2;                                // calls func_2( )
  }
  public int func_2( ) {                     // called from func_2, the last function
    .....;                                   // more statements to be inserted
    MPJ.finalize( );                         // stops mpiJava-A
    return -2;                               // application terminated
  }
}
```

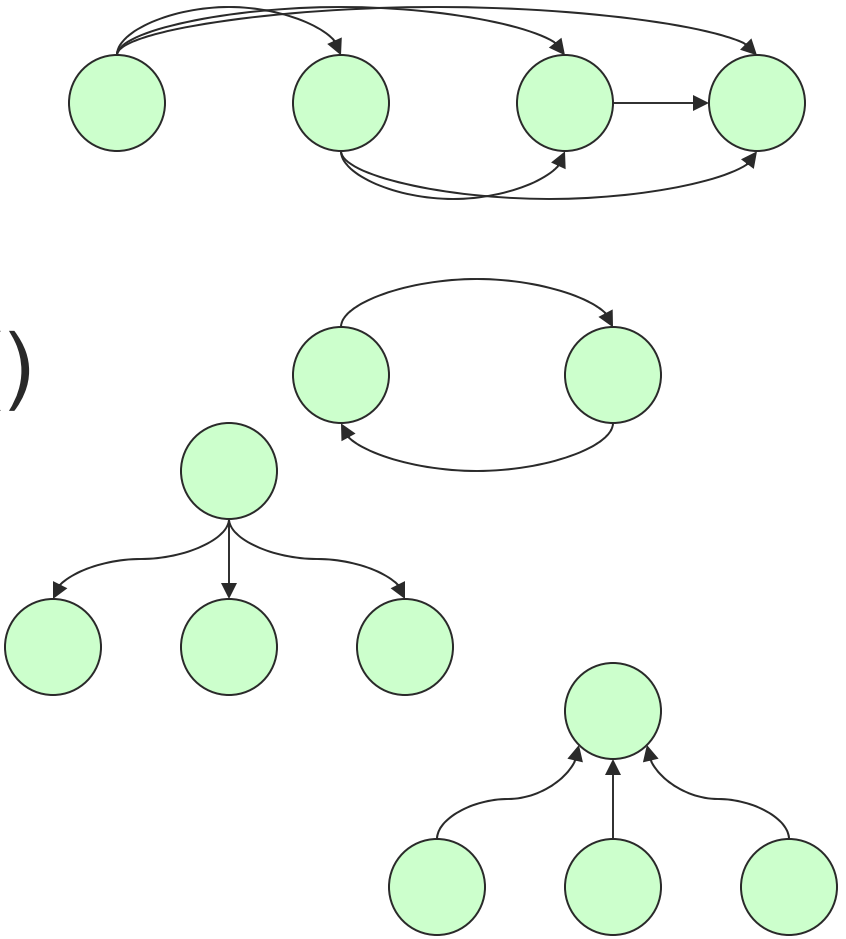
Message Passing Interface

- API that facilitates communications (or message passing) for distributed programs.
- Usually exists for FORTRAN, C/C++, Java.
- Current implementations in Java are actually Java wrappers around native C code.
  - Disadvantages with portability and is not suitable to concept of AgentTeamwork.

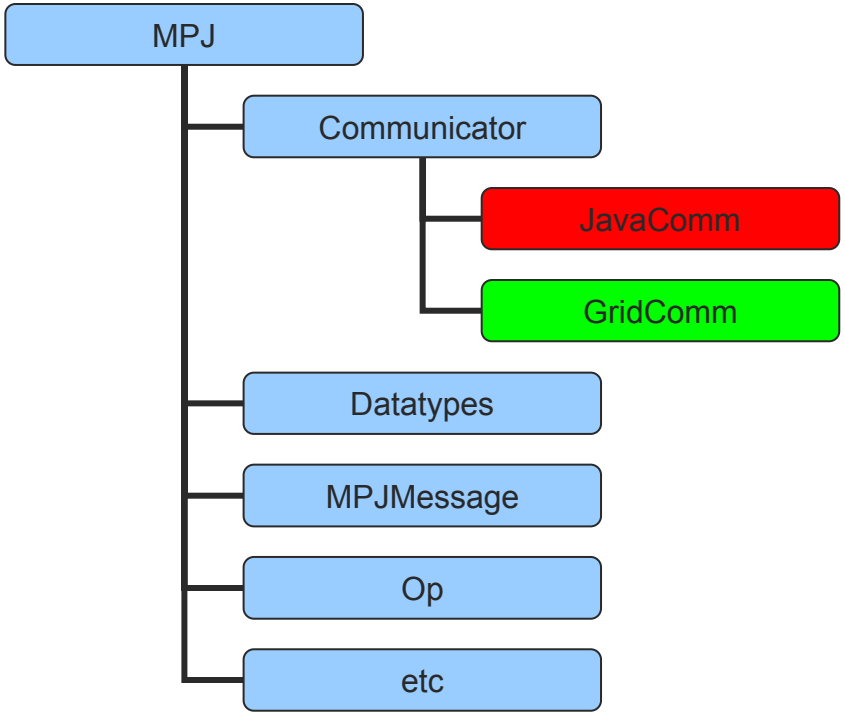


Message Passing Interface – Basic Functions

- Init()
- Send()/Recv()
- Bcast()
- Gather()



MPJ – mpiJavaS & mpiJavaA



MPJ

- Contains main MPI operations.
- Call to traditional Init(string[]) initializes Java socket-based connections.
- Call to Init(string[], IpTable, GridTcp) initializes connections with GridTCP
- Also provides Rank(), Size(), Finalize(), etc.

Communicator

- Provides all communications functions.
- Point to point
  - Blocking – Send(), IRecv()
  - NonBlocking – Isend(), Recv()
- Collective – Gather(), Scatter(), Reduce(), and variants.

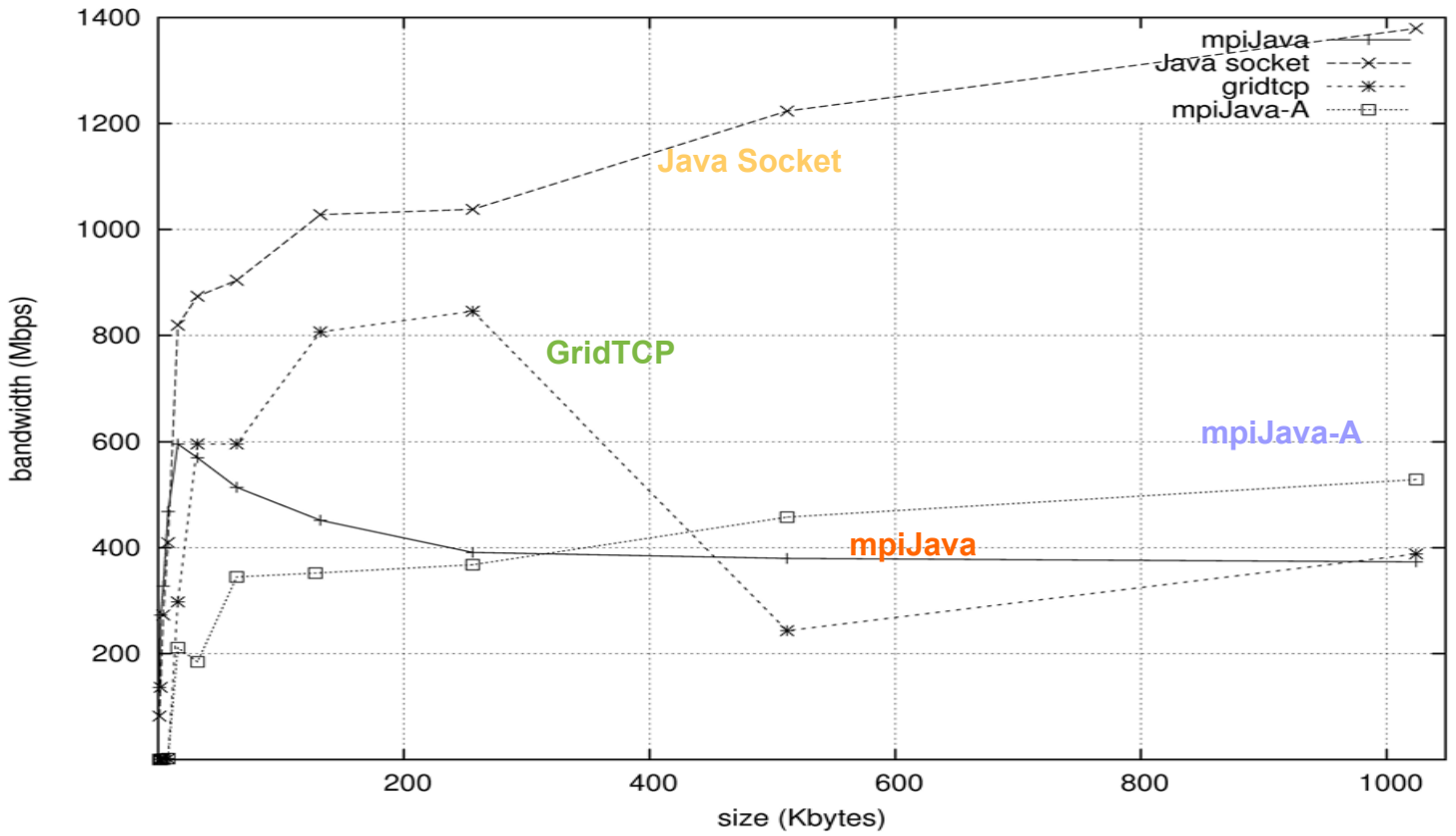
JavaComm & GridComm

- JavaComm:
  - Java Sockets, SocketServers
- GridComm:
  - GridTcp Sockets, GridTcp object, IpTable
  - And others needed by GridTCP.
- Both:
  - InputStreamForRank[]
  - OutputStreamForRank[]
  - Allows for socket communications using bytes.
  - Can use same communications algorithms for both GridComm and JavaComm.
  - Clean interface between the two layers.

Implementation Notes - Performance

- Creation of Java byte arrays/buffers very expensive. Greatly reduces performance.
- One solution: use permanent buffers for serialization
  - byte buffer[64k]
  - Serialize into buffer until full, write buffer, serialize remaining data.
- Not effective with collective communication algorithms.
  - Either requires extra byte storage to handle/save serialized data.
  - Or requires serialization/deserialization at every read/write.

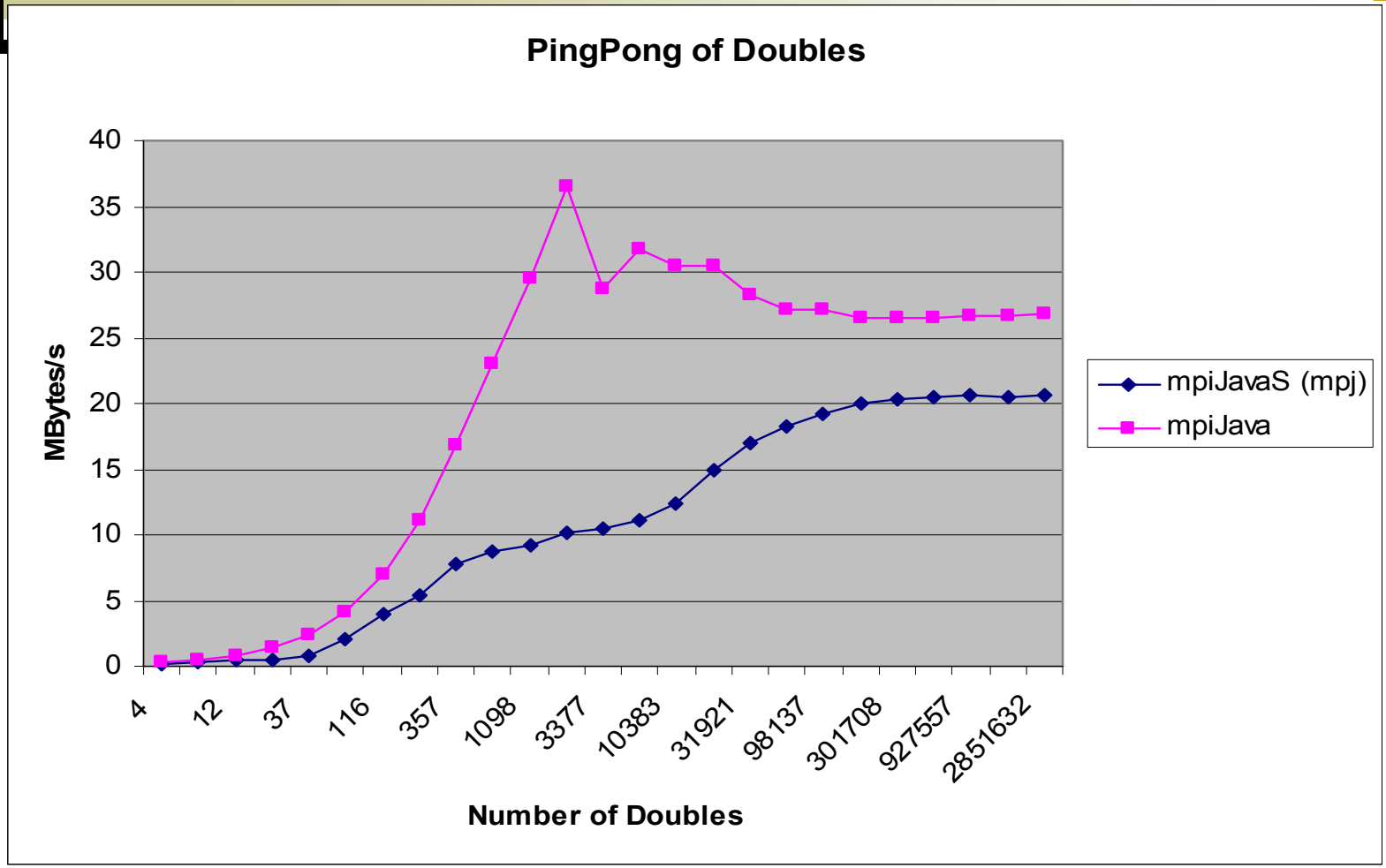
Raw Bandwidth – no serialization (just bytes).



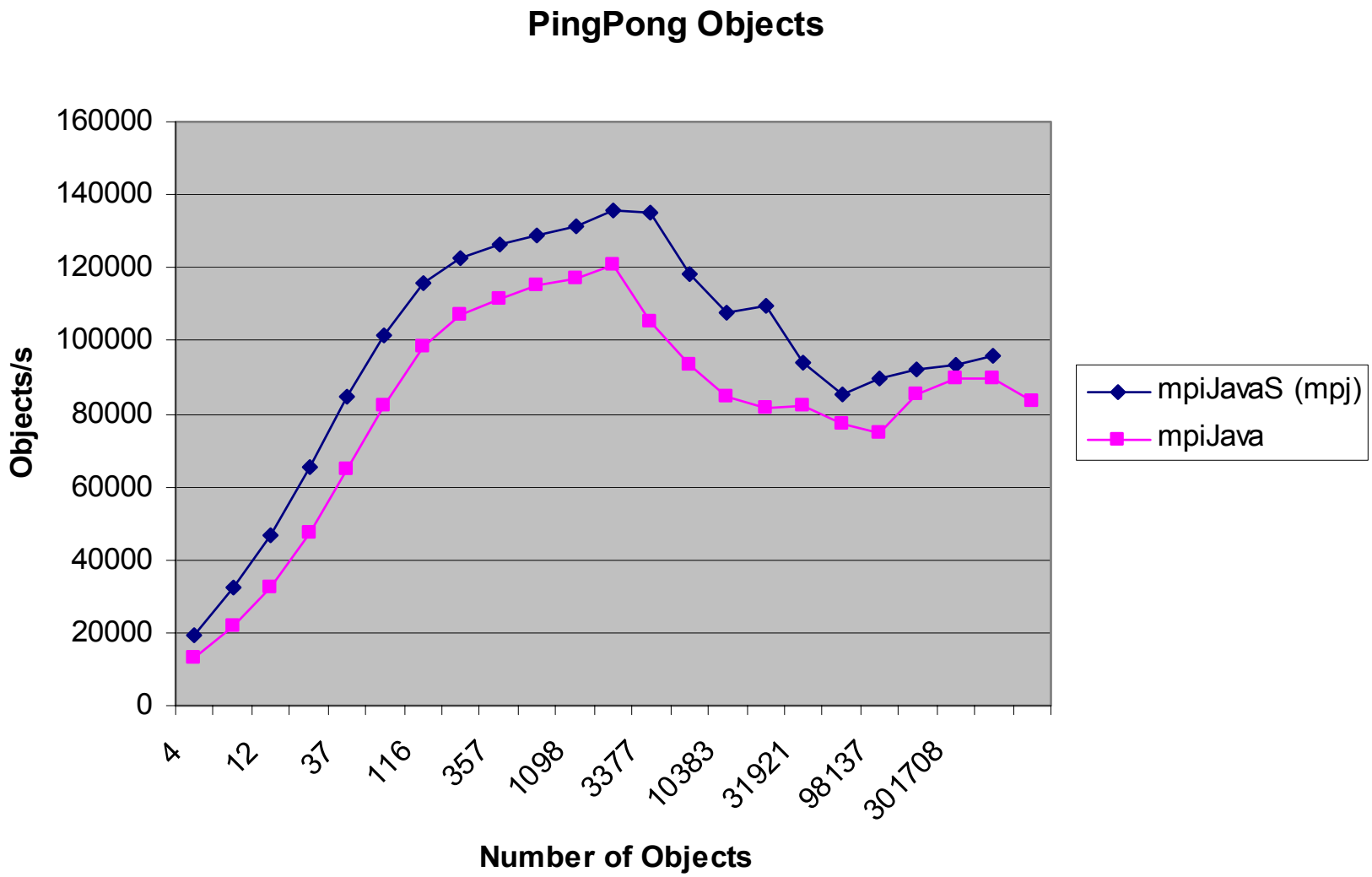
Serialization – Doubles and other primitives

- Doubles - only 20% of performance.
- Other primitives see 25-80% performance.
- Necessity to “serialize” or turn items into bytes very costly
- In C/C++
  - Cast into byte pointer – 1 instruction.
- In Java
  - ```
    int x;                                  //for just 1 integer
    byte[] arr[4];                          //extra memory cost
    arr[3] = (byte) ( x );
    arr[2] = (byte) ( x >>> 8);             //shift, cast, copy
    arr[1] = (byte) (x >>> 16);             //repeat
    arr[0] = (byte) (x >>> 24);
    ```
- Lots of instructions, extra memory for byte buffer.
- Cost x2 due to deserialization on other side.
    ```

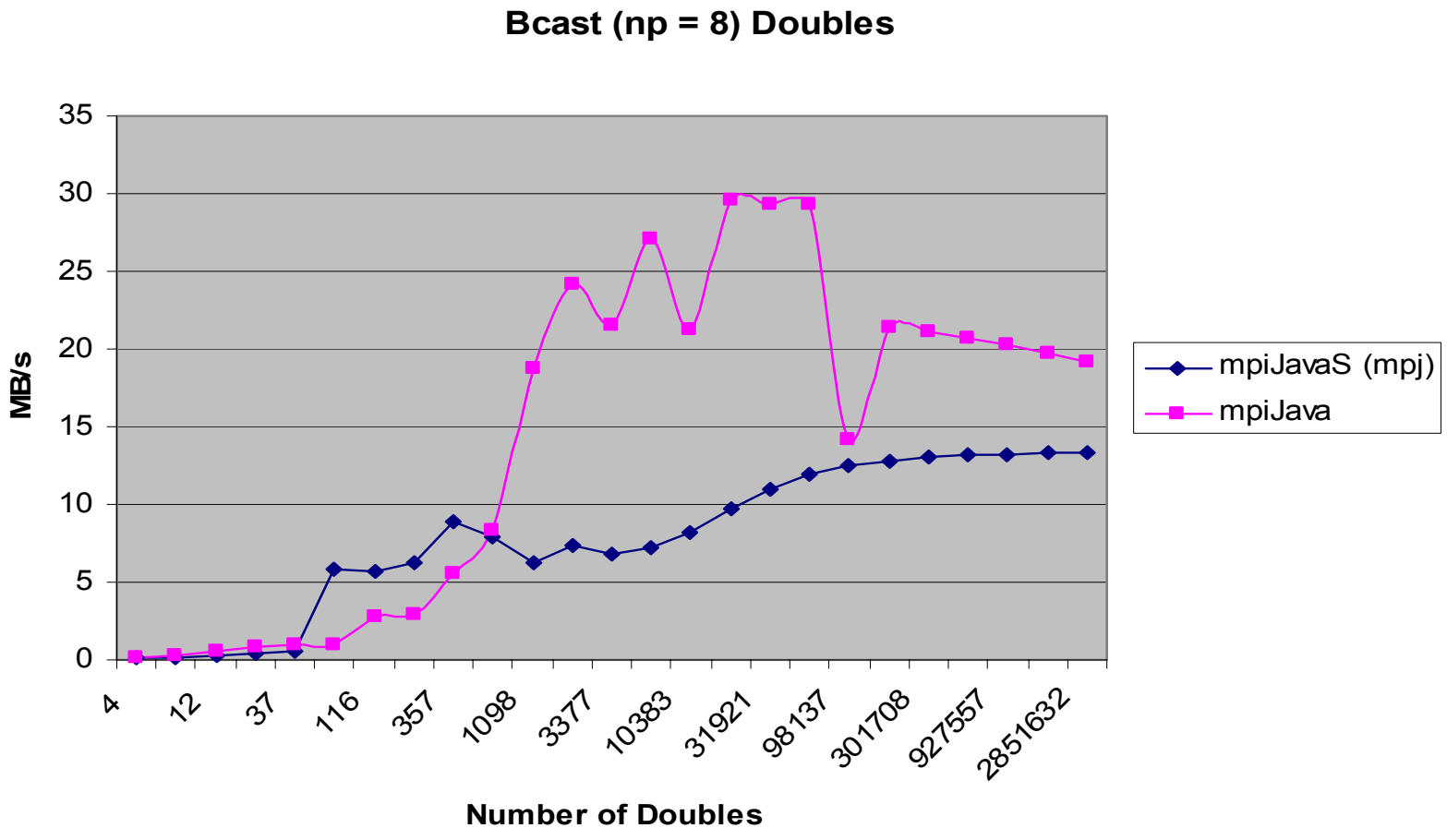
PingPong (send and recv) – Doubles



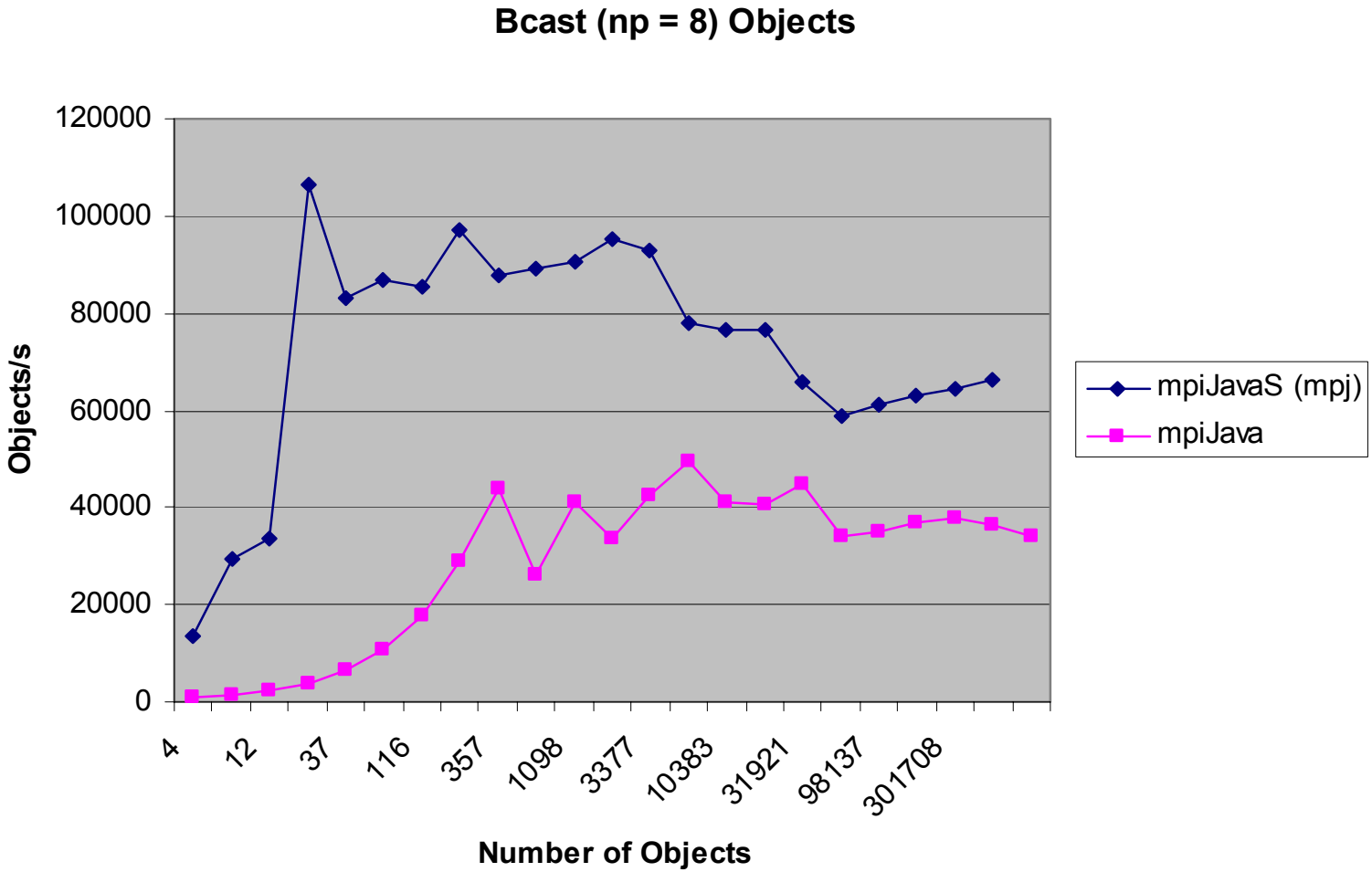
PingPong - Objects



Bcast – 8 processes Doubles



Bcast – 8 processes Objects



Performance Analysis

- Raw bandwidth
  - mpiJavaS comes to about 95-100% of maximum Java performance.
  - mpiJavaA (with checkpointing and error recovery) incurs 20-60% overhead, but still overtakes mpiJava with bigger data segments.
- Doubles & Objects
  - When dealing with primitives or objects that need serialization, a 25-50% overhead is incurred.
- Memory issues related to mpiJavaA – runs out of memory.

Conclusion

- The next step is to develop a tool to automatically parses a user program into GridTcp functions for best performance.
- Ultimately, automate user job distribution, management, and error recovery.

A few helpful classes…

- CSS432 Networking
- CSS430 Operating Systems
- CSS360 Software Engineering
- CSS422 Hardware
- CSS343 Data Structures & Algorithms

MPJ – mpiJavaS & mpiJavaA

Questions?