# Using Java for Plasma PIC Simulations

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# High Performance Java

1. Can Java be used for parallel computing?

2. Can Java deliver performance comparable to Fortran/C?

Java Grande Forum since 1998

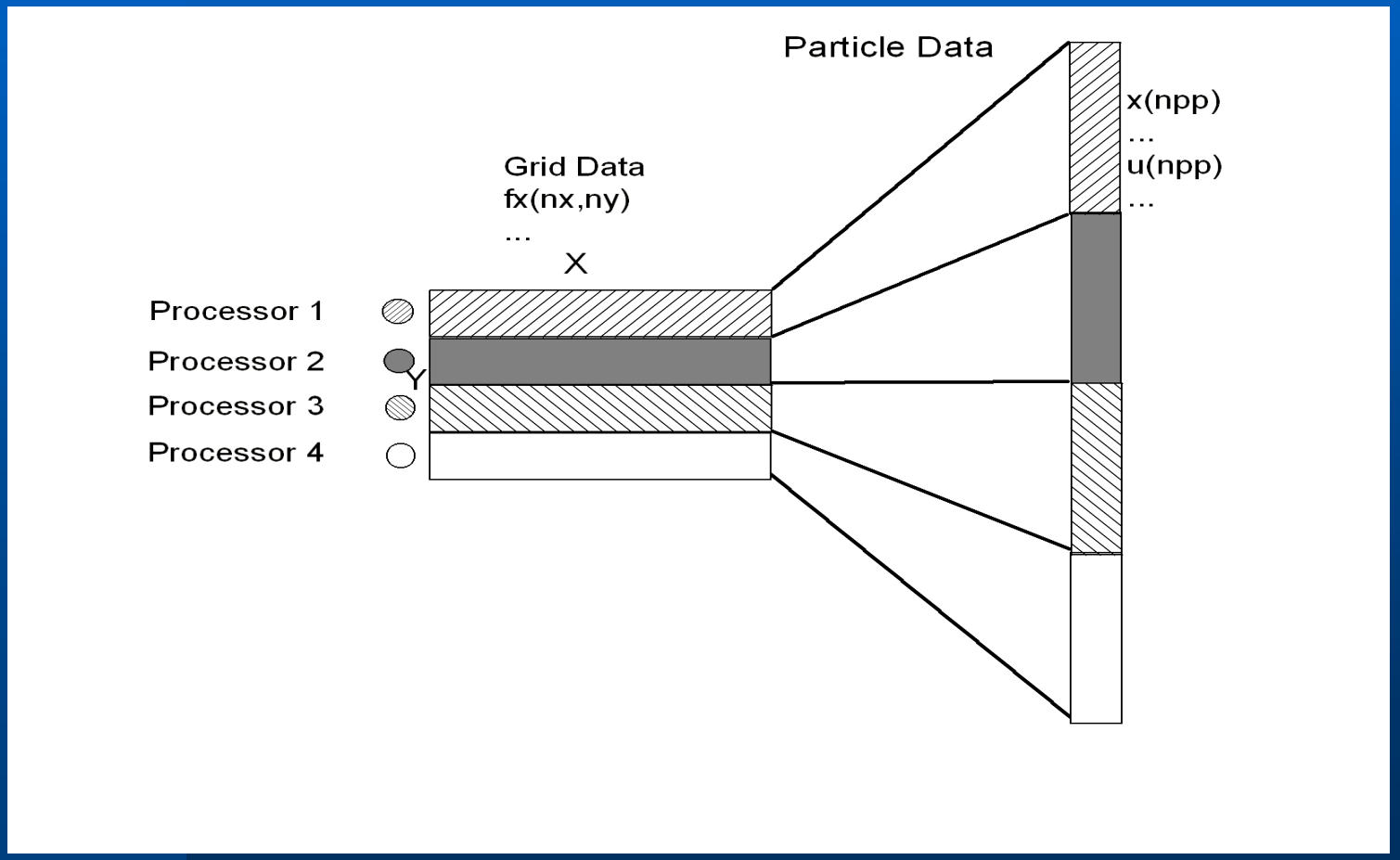
# Distributed and High Performance Group at Westminster

- Message passing for Java
- Automatic wrapper generator
- Wrapped existing message-passing libraries - MPI
- Wrapped scientific libraries - BLAS, BLACS, LAPACK, ScaLAPACK, etc.
- Needed an application case study

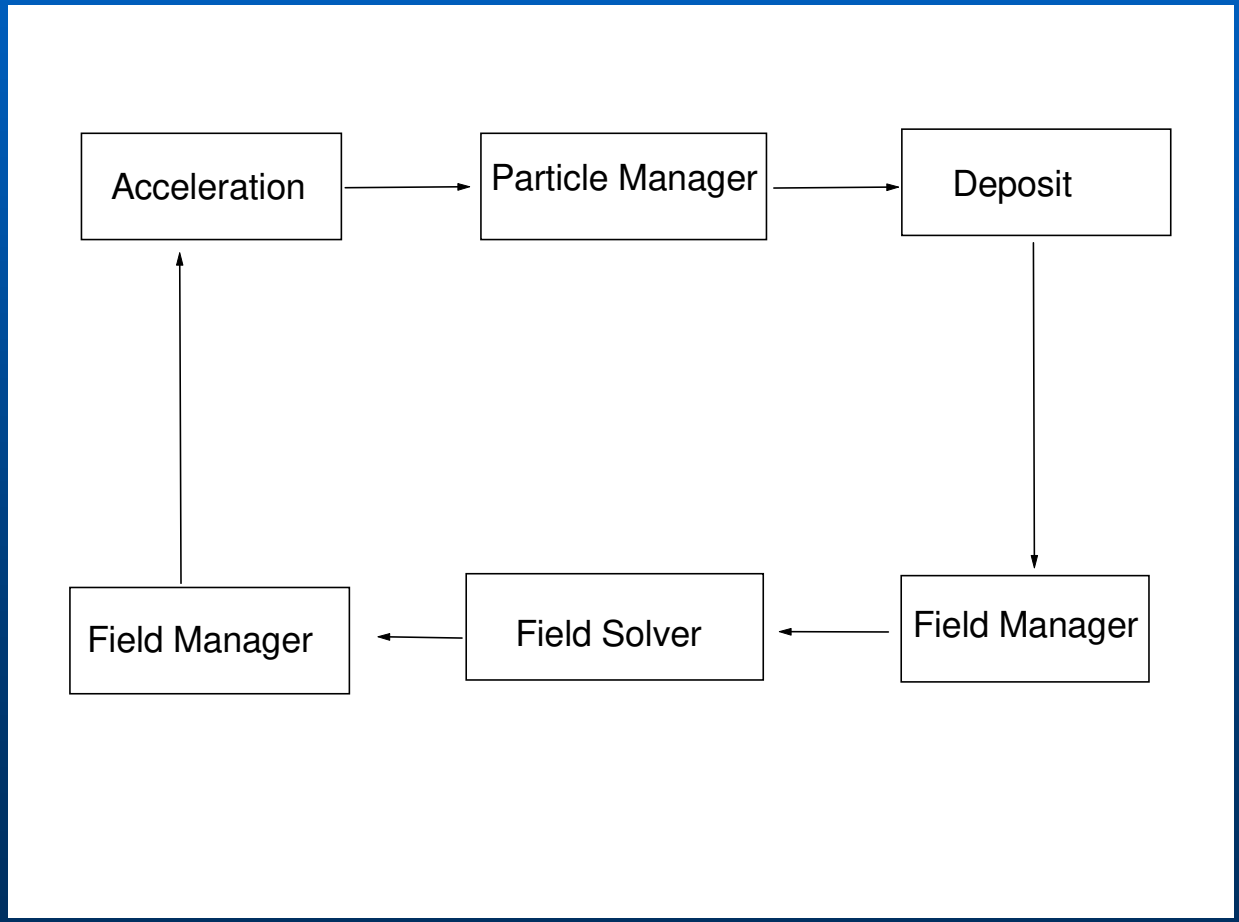
# The Skeleton plasma PIC code

- Electrostatic code - move only electrons
- The physical problem is a plasma beam instability
- Quadratic spline functions for interpolation
- It is a good testbed for parallel computing

# Grid and particle partitioning



# General structure of the PIC skeleton



# Our 2D and 3D PIC codes in Java

- Two main Java classes: “plasma” and “field” which are based on “PICSimulator”.
- The “PICSimulator” class defines some basic parameters.

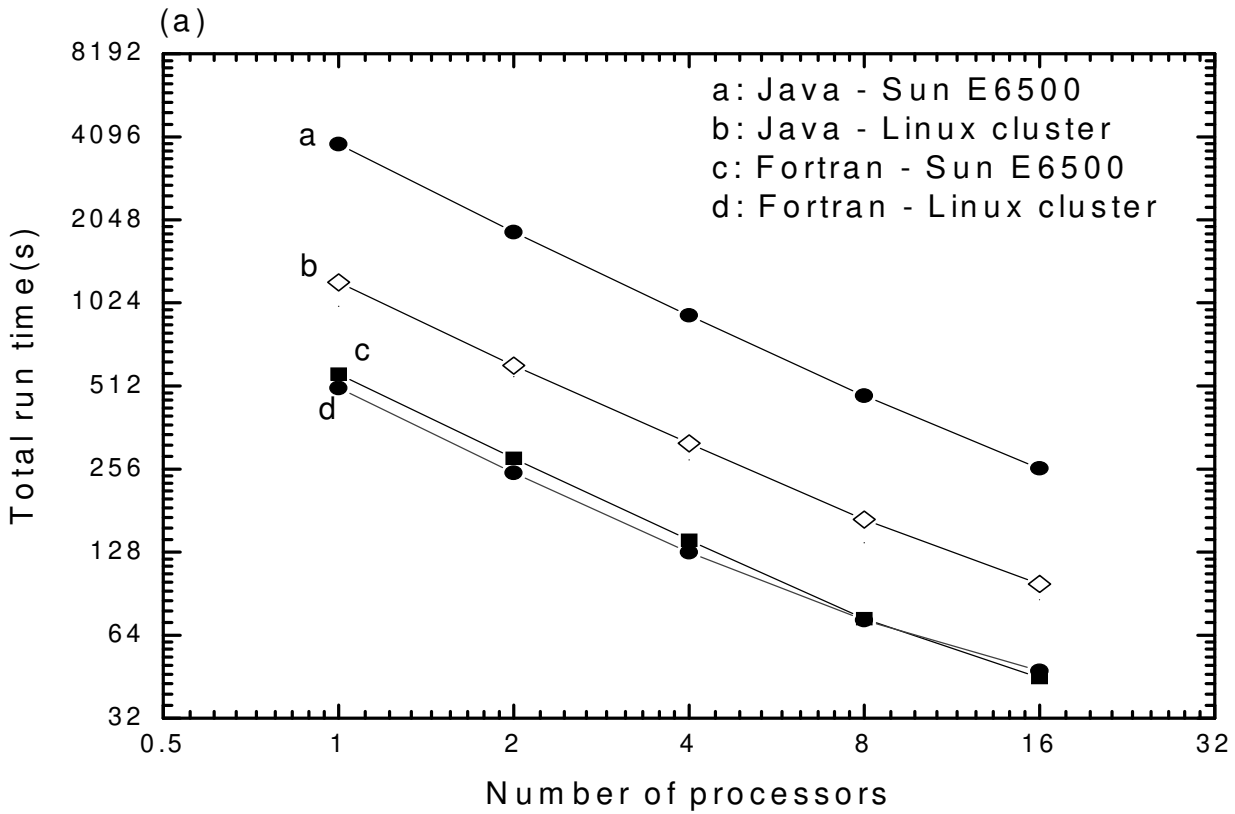
# Performance Experiments

1. Codes: 2D and 3D plasma PIC codes.
2. Computers:

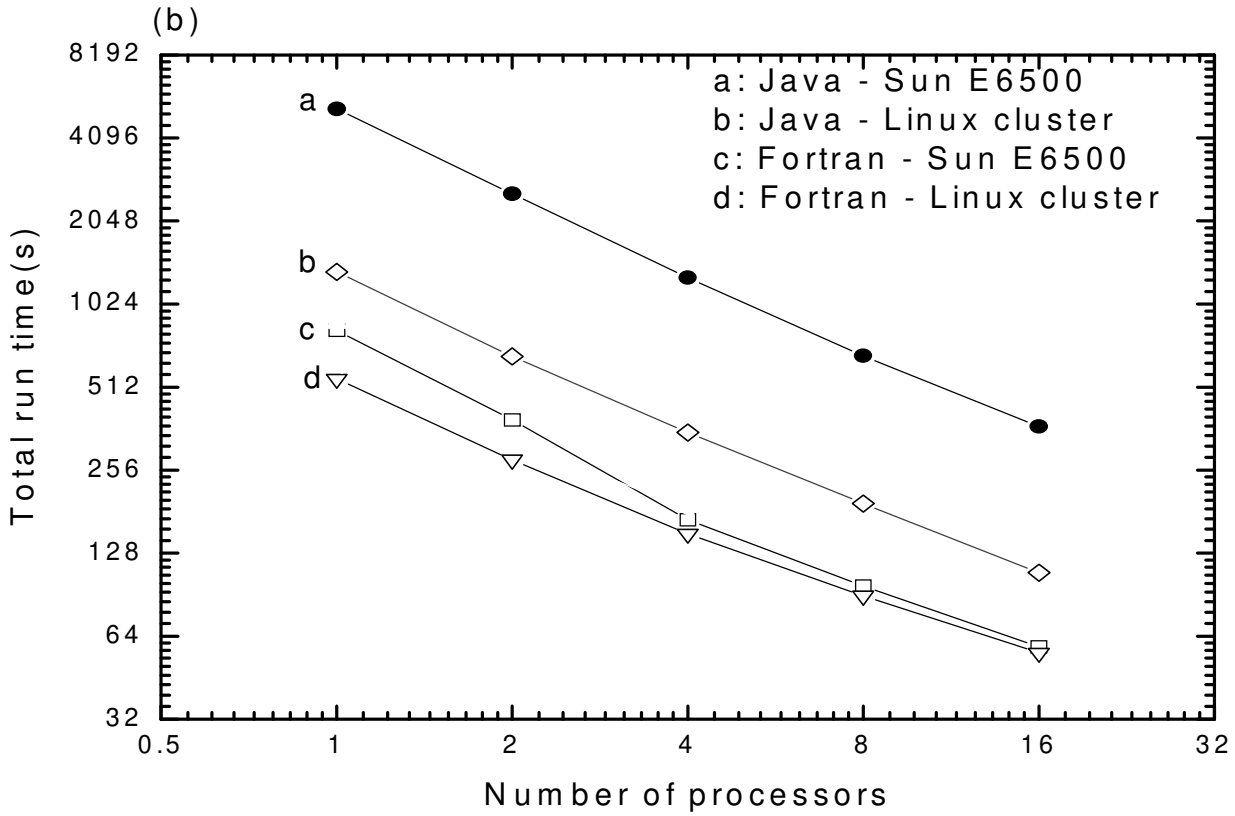
- Sun E6500: 30*336MHz Ultra Sparc 2 processors with shared memory, Solaris 2.6. Sun JDK 1.3, Sun Fortran F90 2.0., Sun MPI 2.0
- Linux cluster: 16*900MHz Pentium III processor, RedHat 6.2, Sun JDK 1.4, Gnu Fortran 77, MPICH1.2, 100Mb/s switch.

3.Java interface to MPI: MPJ RI (mpiJava1.2.)

# Total runtime versus number of processors - 2D PIC codes



# Total runtime versus number of processors - 3D PIC codes



# Runtime of main parts of the 2D PIC codes on Sun E6500

| No. of proc | Fortran | | Java | |
|---|---|---|---|---|
| | Particle time | Field time | Particle time | Field time |
| 1 | 549.86 | 15.60 | 3780.68 | 69.06 |
| 2 | 272.33 | 7.73 | 1800.93 | 47.33 |
| 4 | 136.49 | 4.80 | 893.18 | 28.47 |
| 8 | 69.45 | 3.94 | 451.70 | 20.13 |
| 16 | 39.31 | 5.59 | 243.33 | 13.74 |

# Runtime of main parts of the 2D PIC codes on the PC cluster

| No. of proc | Fortran | | Java | |
|---|---|---|---|---|
| | Particle time | Field time | Particle time | Field time |
| 1 | 488.26 | 15.05 | 1194.92 | 20.10 |
| 2 | 239.36 | 8.71 | 592.21 | 15.03 |
| 4 | 123.19 | 4.57 | 305.87 | 11.64 |
| 8 | 68.55 | 4.06 | 158.18 | 9.89 |
| 16 | 43.20 | 4.28 | 89.41 | 8.64 |

# Runtime of main parts of the 3D PIC codes on Sun E6500

| No. of proc | Fortran | | Java | |
|---|---|---|---|---|
| | Particle time | Field time | Particle time | Field time |
| 1 | 794.10 | 27.83 | 5222.12 | 126.89 |
| 2 | 353.82 | 35.06 | 2567.14 | 116.18 |
| 4 | 154.02 | 15.34 | 1275.15 | 69.92 |
| 8 | 83.32 | 14.06 | 663.68 | 73.89 |
| 16 | 41.02 | 17.53 | 368.08 | 51.67 |

# Runtime of main parts of the 3D PIC codes on the PC cluster

| No. of proc | Fortran | | Java | |
|---|---|---|---|---|
| | Particle time | Field time | Particle time | Field time |
| 1 | 526.64 | 20.57 | 1298.93 | 40.23 |
| 2 | 264.56 | 17.49 | 627.16 | 33.73 |
| 4 | 134.77 | 15.28 | 322.09 | 28.48 |
| 8 | 74.62 | 14.95 | 168.01 | 25.57 |
| 16 | 40.32 | 15.36 | 87.40 | 21.38 |

# Conclusions and future work

- 2D and 3D PIC codes successfully ported to Java - http://perun.hscs.wmin.ac.uk
- This first (naïve) port delivers relatively low performance - 15% of Fortran on Sun E6500 and 45% of Fortran on our Linux cluster.
- Optimizations using pure Java
- Mixed Java/Fortran code
- Comparisons with multithreading
- Porting to a Grid environment