UPC Applications

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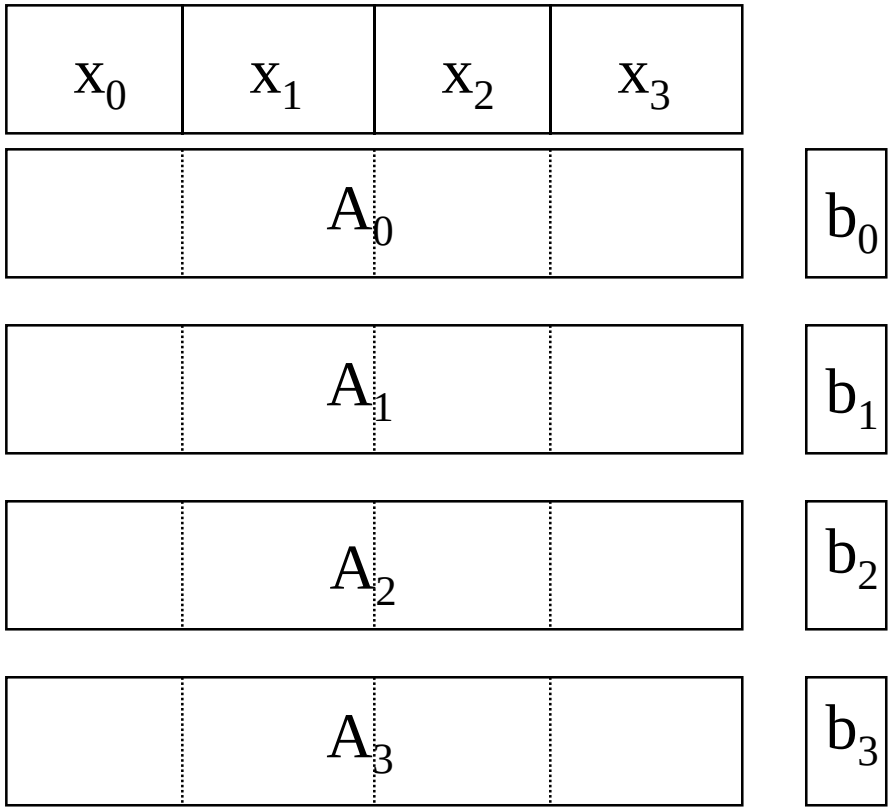
Roadmap

- Benchmark small applications and kernels
  - —SPMV (for iterative linear/eigen solvers)
  - —Multigrid
- Develop sense of portable UPC programming style (using T3E and Compaq AlphaServer)
- Motivate and evaluate compiler optimizations
- Move to larger applications
  - —Candidates should be hard with current techniques:
    Large N-body problems
    Sparse Direct Methods
    3-D Mesh Generation
    ...

Sparse Matrix-Vector Multiplication

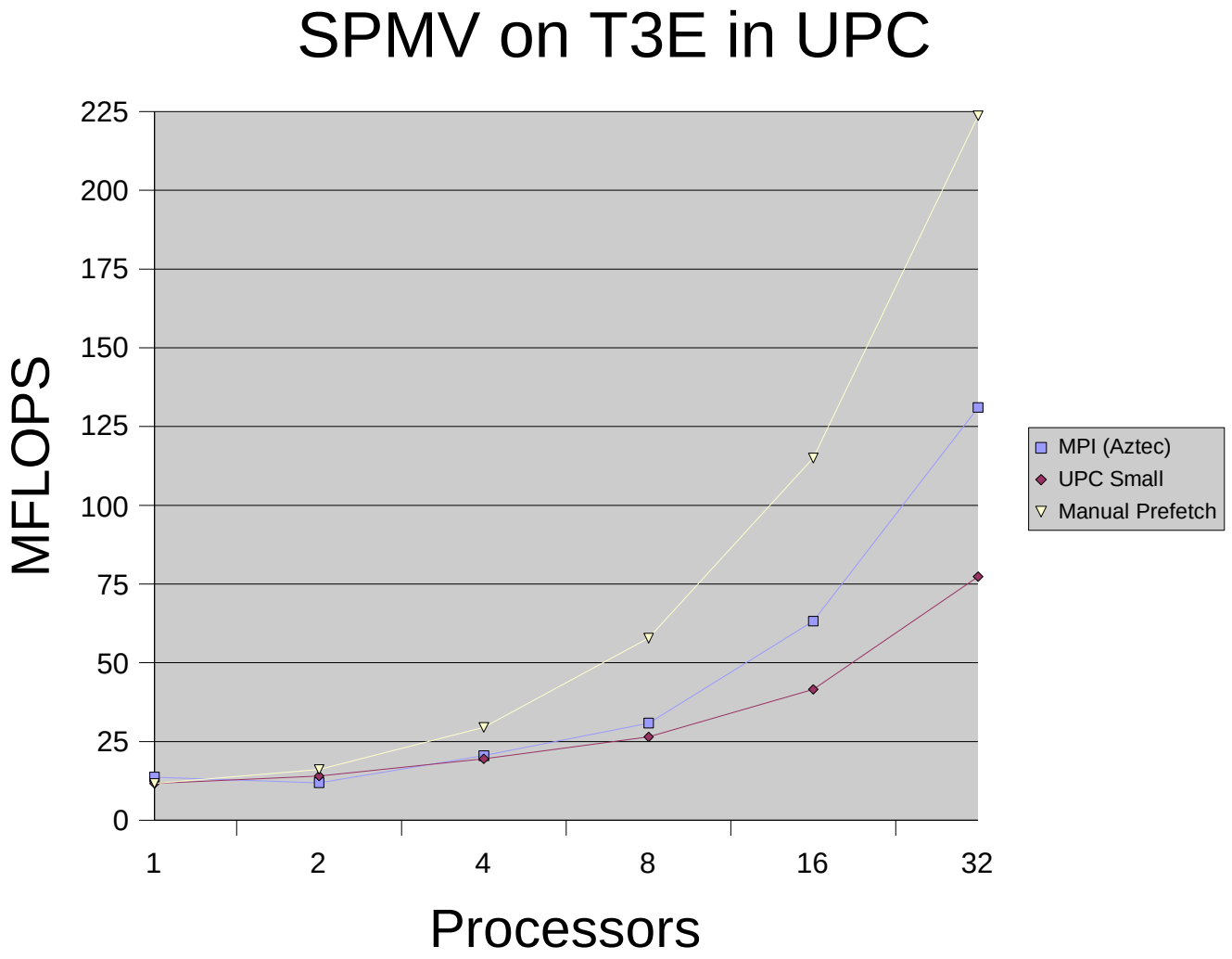
- Ax=b with A sparse
- Distributed Compressed Row Format Used for A
- Vectors distributed across processors
- Communication of elements of x needed to compute b



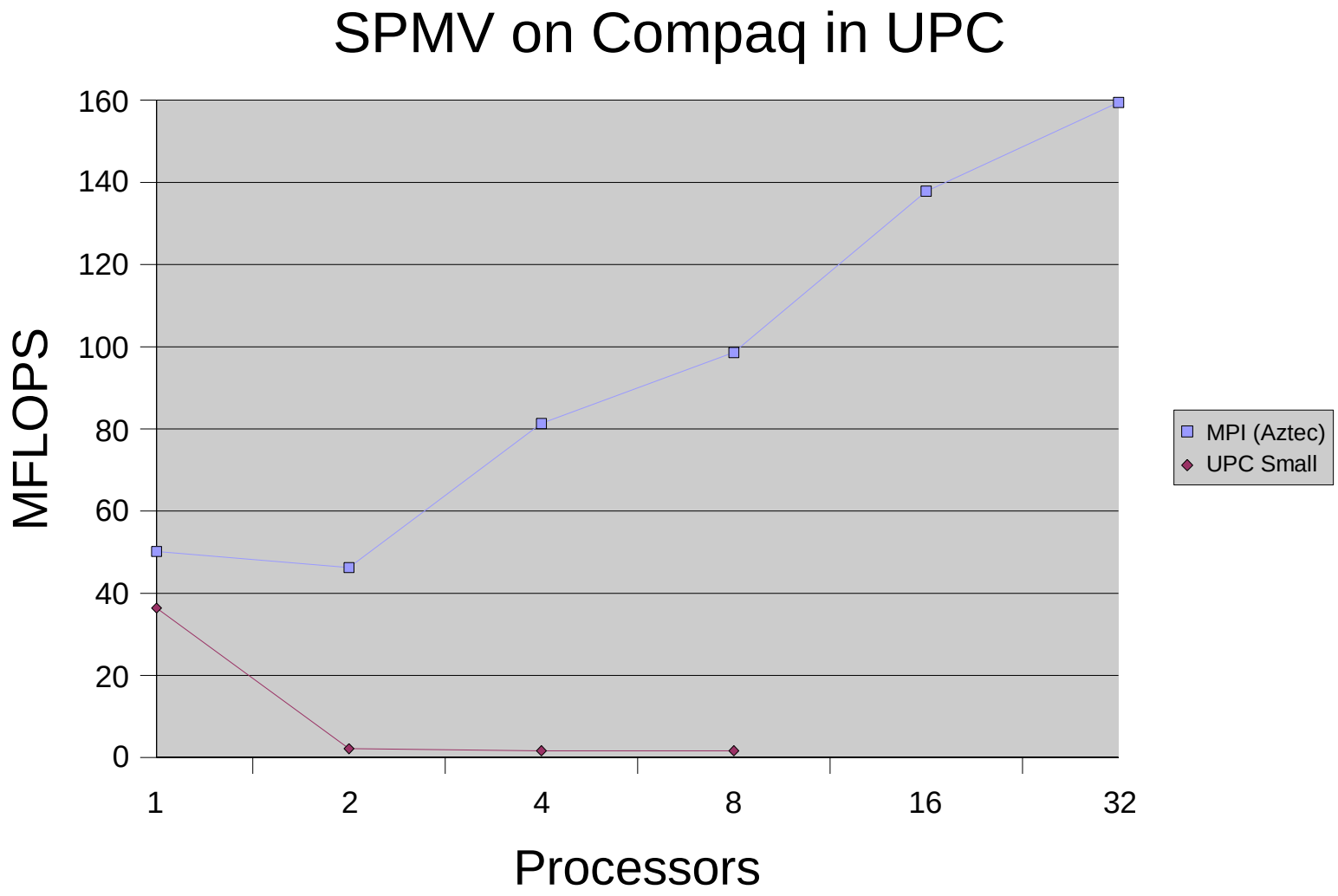
Communication Strategies

- Need to send elements of x to processors that need them
  - —Individual sends?
  - —Pack?
  - —Prefetch?
- Try to overlap communication with computation
  - —Initiate communication
  - —Do some local computation
  - —Wait for remote elements
  - —Compute on remote elements

T3E Results

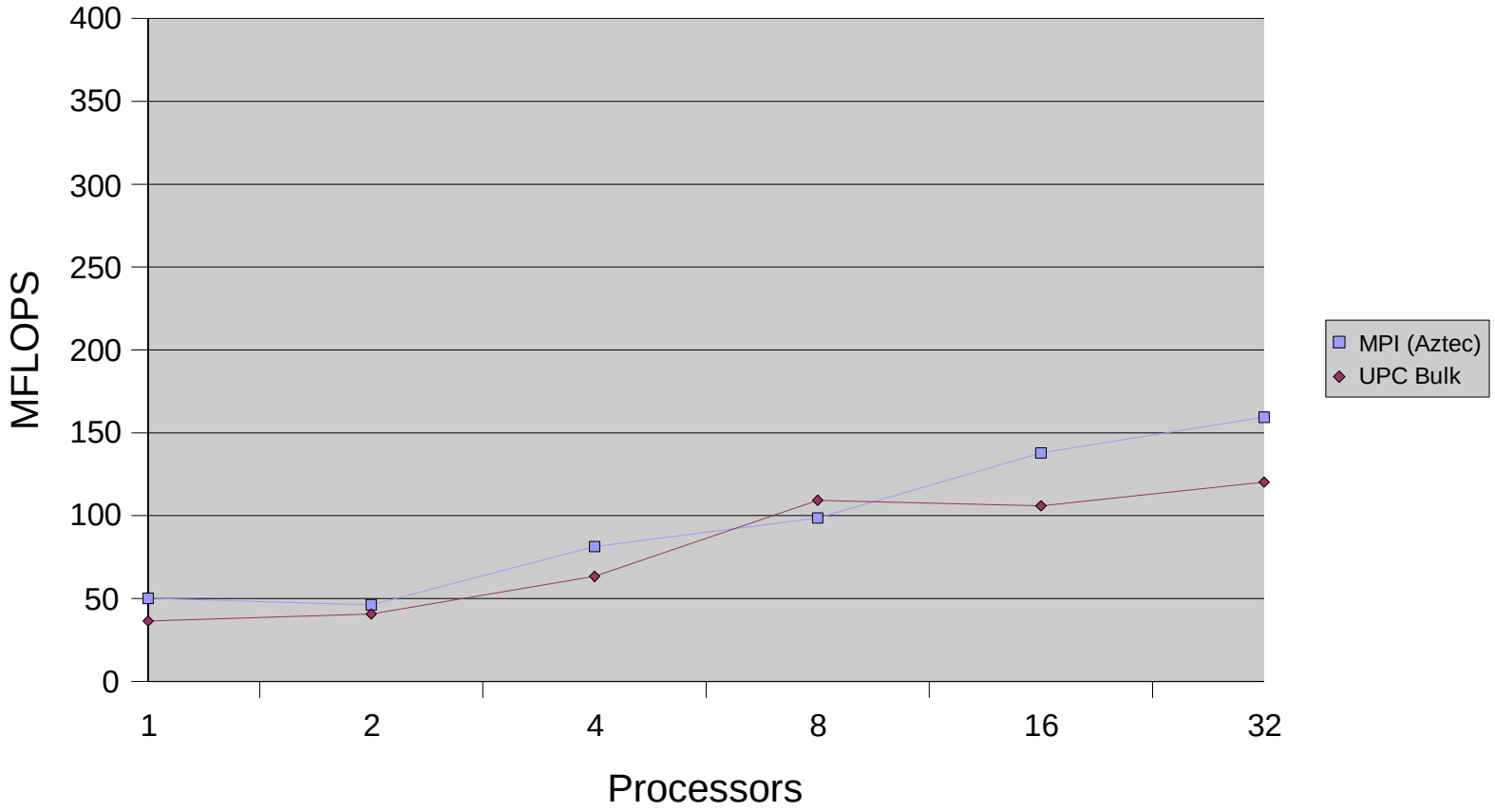

SPMV on T3E in UPC
MFLOPS
225
200
175
150
125
100
75
50
25
0
1
2
4
8
16
32
Processors
MPI (Aztec)
UPC Small
Manual Prefetch

Compaq Results (1)



Compaq Results (2)

SPMV on Compaq in UPC and MPI (4 procs/node)



Discussion

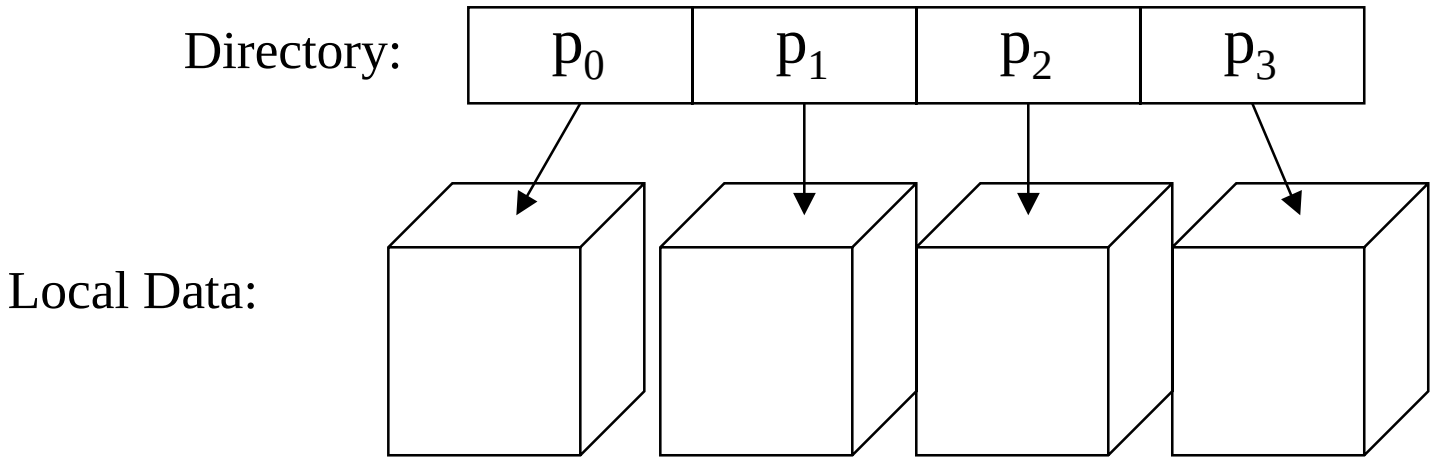
- Small message version required access to low latency messaging for performance
  - Manually done on T3E
  - Under investigation on Compaq
- Pack/Unpack version gives best portable performance
  - Relies on large messages (usually best performing)
  - Requires more source code
  - Investigating inspector/executor techniques
- Proposal
  - Make life easy for the compiler and add a pragma:
    #pragma prefetch(vector,indices)

Multigrid

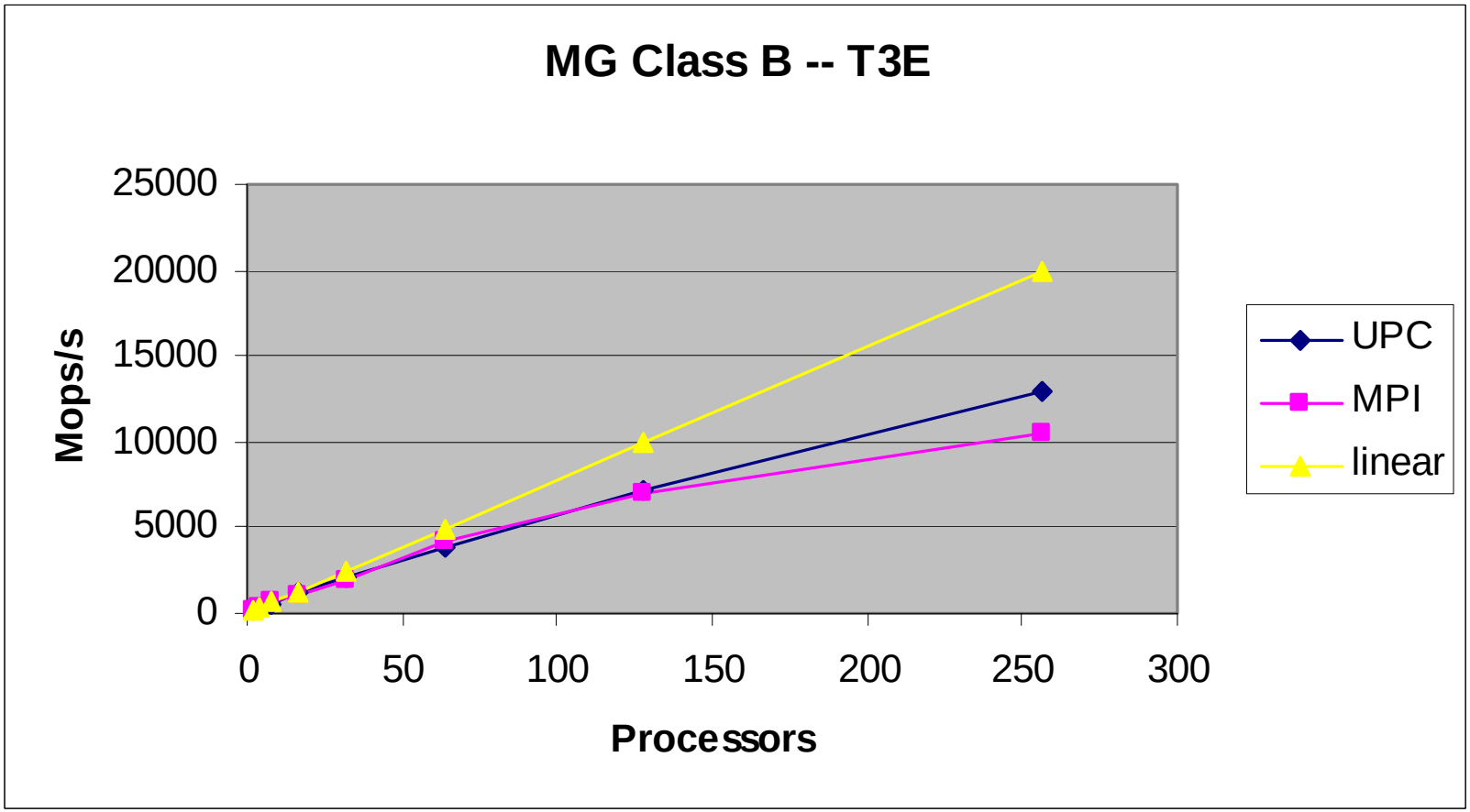
- Taken from NAS Parallel Benchmarks
  - —Hierarchy of grids (256^3->2^3)
  - —Project down to coarsest grid
  - —Solve
  - —Prolongate and smooth back up to finest grid
- Operators all involve nearest neighbour computations in 3-d and ghost region exchanges
- Code based on OpenMP version from RWCP
- Simple domain decomposition scheme used to map 3-d grid to a 3-d processor grid.
- On T3E computation compiled with CC (multidimensional array performance poor with gcc)

Data Structures

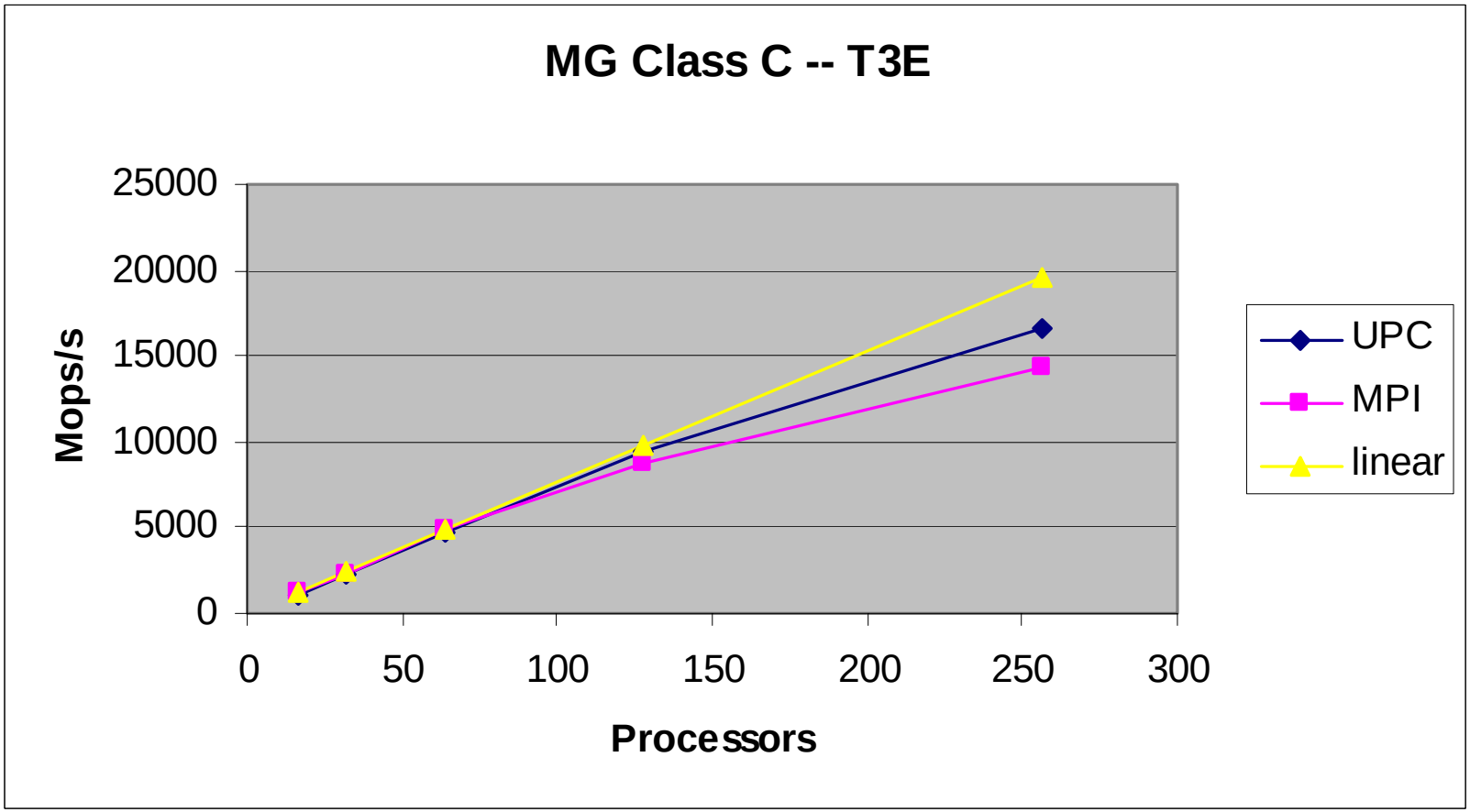
- **For grid large, static distributed array not feasible**
  - **Difficult to change sizes at runtime**
  - **Need to access through local pointers for performance (avoid A[i] for pointer to shared A)**
- **Pointers to local regions (upc_local_alloc()'d) used instead**
  - **Can easily access any global element**
  - **Directory can be cached locally**



T3E Results – Class B (256^3)



T3E Results – Class C (512^3)



Discussion

- Outperform MPI Fortran version on T3E!
- Single processor performance an issue
- No speedups past 8 processors on Compaq
  - —Spins to signal incoming variables
  - —May need to reorganize communication
- No small message version yet. Probably not worth it on Compaq.