Silicon Graphics Scientific Library Update

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Supercomputing Applications

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Contents

- Scientific Libraries available on SGI hardware
- SCSL Scientific Library
  (like “SGI”, “SCSL” doesn’t mean anything ;-))
- SCSL Release 1.2
- Signal Processing in SCSL 1.2
- Performance
- Special Solvers in SCSL 1.2
- Future

Scientific Libraries on SGI

There are "many" scientific libraries available on SGI platforms today.

- **LibSci on Cray platforms.**
- **CHALLENGEcomplib on IRIX platforms. (libcomplib.sgimath,libblas)**
  - **Part of the IDO in IRIX 6.4 and older**
  - **Part of the IRIX development libraries in IRIX 6.5**
  - **Version 3.1**
- **SCSL on IRIX platforms.**
  - **Unbundled product**
  - **Available for IRIX 6.4 and newer**
  - **Version 1.1**

SCSL Scientific Library

- SCSL is a scientific and math library
- SCSL is (initially) available on IRIX 6.4 and 6.5 systems
- SCSL will become the standard scientific library on all SGI platforms
- SCSL will merge the important functionality of CHALLENGEcomplib and LibSci into one library
- SCSL will provide a new library with more functionality and better performance than either library by itself.

SCSL Contents

- BLAS (Basic Linear Algebra Subprograms).
  - BLAS1–Vector–vector operations
  - BLAS2–Matrix–vector operations
  - BLAS3–Matrix–matrix operations
- LAPACK
  - Symmetric and Nonsymmetric linear systems of equations
  - Symmetric and Nonsymmetric eigenvector/value
  - Singular Value Decomposition
  - Linear Least Squares

BLAS and LAPACK developed at the University of Tennessee.

SCSL Contents (continued)

- Sparse Linear Equation Solvers
  - Symmetric linear systems of equations
  - Nonsymmetric linear systems of equations (NO pivoting)
- FFTs
  - multiple one-dimension mixed radix
  - one-,two-and three-dimension mixed radix
  - single-and double-precision, for both real and complex data types

Sparse solvers and FFTs were developed at SGI. (There is no defacto standard API).

How to use SCSL

- Documentation in form of man pages:
  - intro_libscsl
  - intro_blas1, _blas2, _blas3
  - intro_fft
  - intro_lapack
  - intro_sparse (soon)
  - these will point you to more detailed man pages
- Linking:
  - Serial: -lscs
  - OpenMP or libmp parallel:
    -lscs_mp -mp

SCSL Release 1.2

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SCSL 1.1 is the current release.
Release 1.2 will be the next SCSL release.

Goals for 1.2:

- Add the missing complib Signal Processing functionality.
- Provide C language interfaces for the Signal Processing routines.
- Enhance the ordering techniques in the sparse linear solvers.
- Performance tuning for the MIPS R12000 Processor.
- Rollup bug fixes from SCSL 1.1 and complib 3.1.

SCSL 1.2 will be released with IRIX 6.5.5 (late July 1999).

SCSL Release 1.2 (continued)

SCSL 1.2 is the follow-on to CHALLENGEcomplib with some exceptions:

- SCSL 1.2 will NOT include o32 versions of the libraries.
- SCSL 1.2 will NOT support LINPACK and EISPACK.
- SCSL 1.2 will run on all platforms that have n32 or 64 support.

CHALLENGEcomplib is available to run on older and current platforms,however:

- There will be no further releases of complib.
- No complib bugs fixes (with rare exceptions).

Signal Processing for SCSL 1.2

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Additions to the FFTs:

- multiple 1D routine which calculates an FFT in one dimension for each *row* of a two-dimensional matrix.
- 1D, 2D and 3D routines that compute the product of the Fourier Transform of a sequence with the Fourier Transform of a filter (*prod routines in complib).
- Functions will be introduced to release memory allocated within the FFT routines.
- C language bindings.

Signal Processing for SCSL 1.2 (continued)

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SCSL 1.2 will include convolution and correlation routines.

- **Convolution for Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) filters, together with Correlations.**
- **1D and 2D convolution and correlation**

  Single and double precision for real and complex arithmetic.
- **2D routines will run on multiple processors.**
- **API similar to complib API (but not fully compatible).**
- **Fortran and C language bindings.**

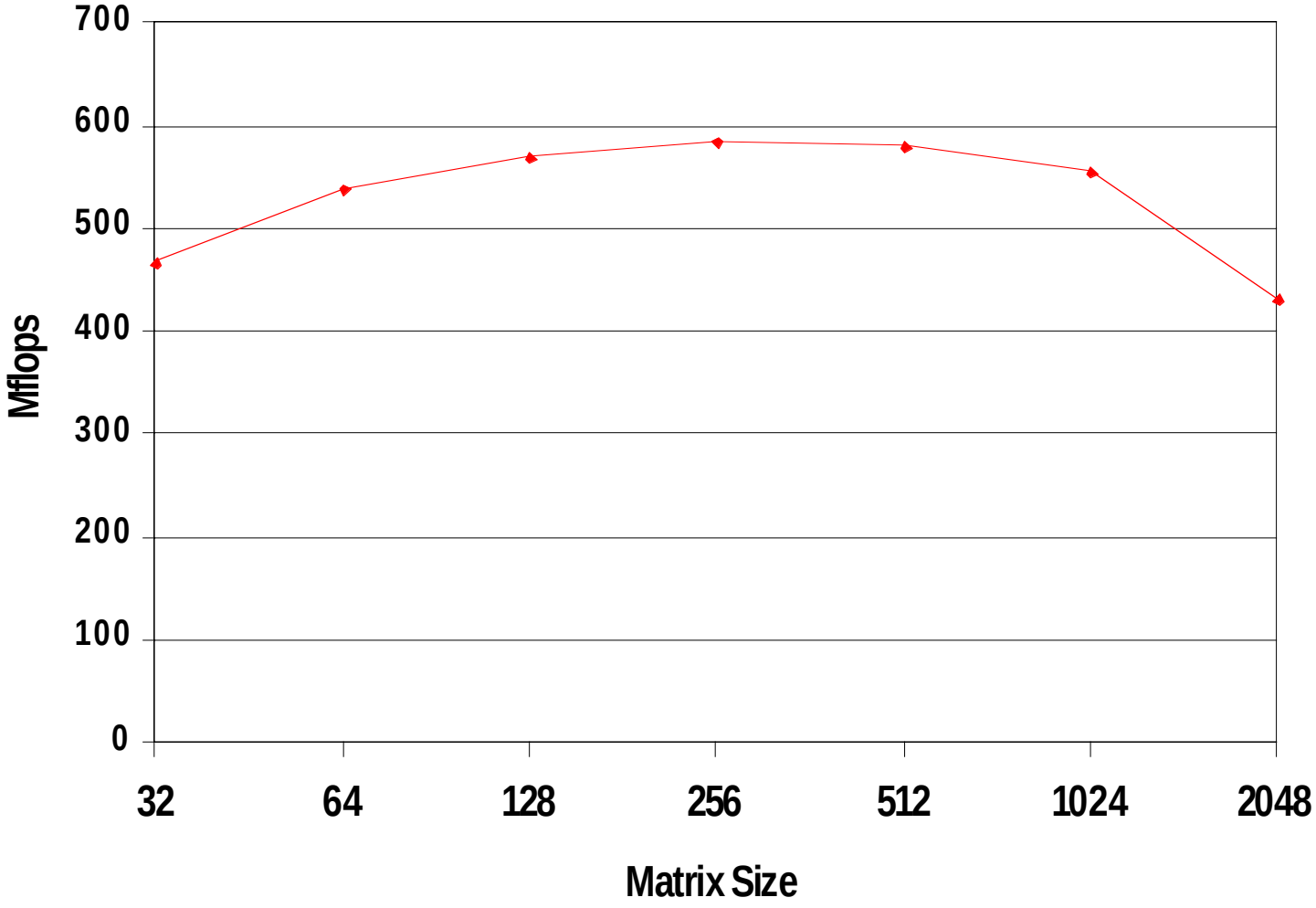
The two main goals of the Convolution and Correlation library are **performance** ***and*** **generality**. ***It provides well tuned modules usable in most convolution and correlation instances.***

Performance

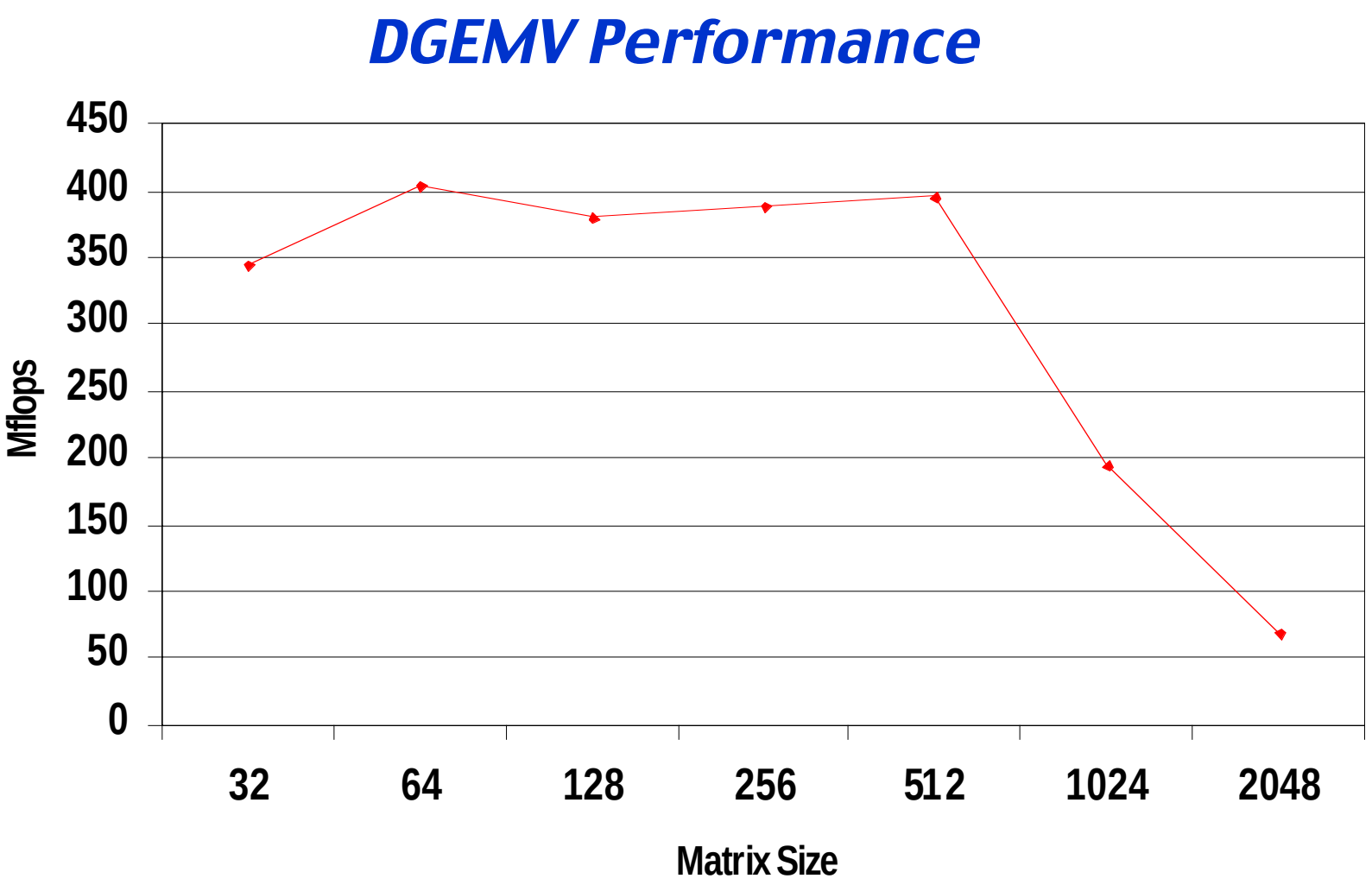
- BLAS
- Fast Fourier Transforms
- Sparse Solver

BLAS Performance

DGEMM Performance

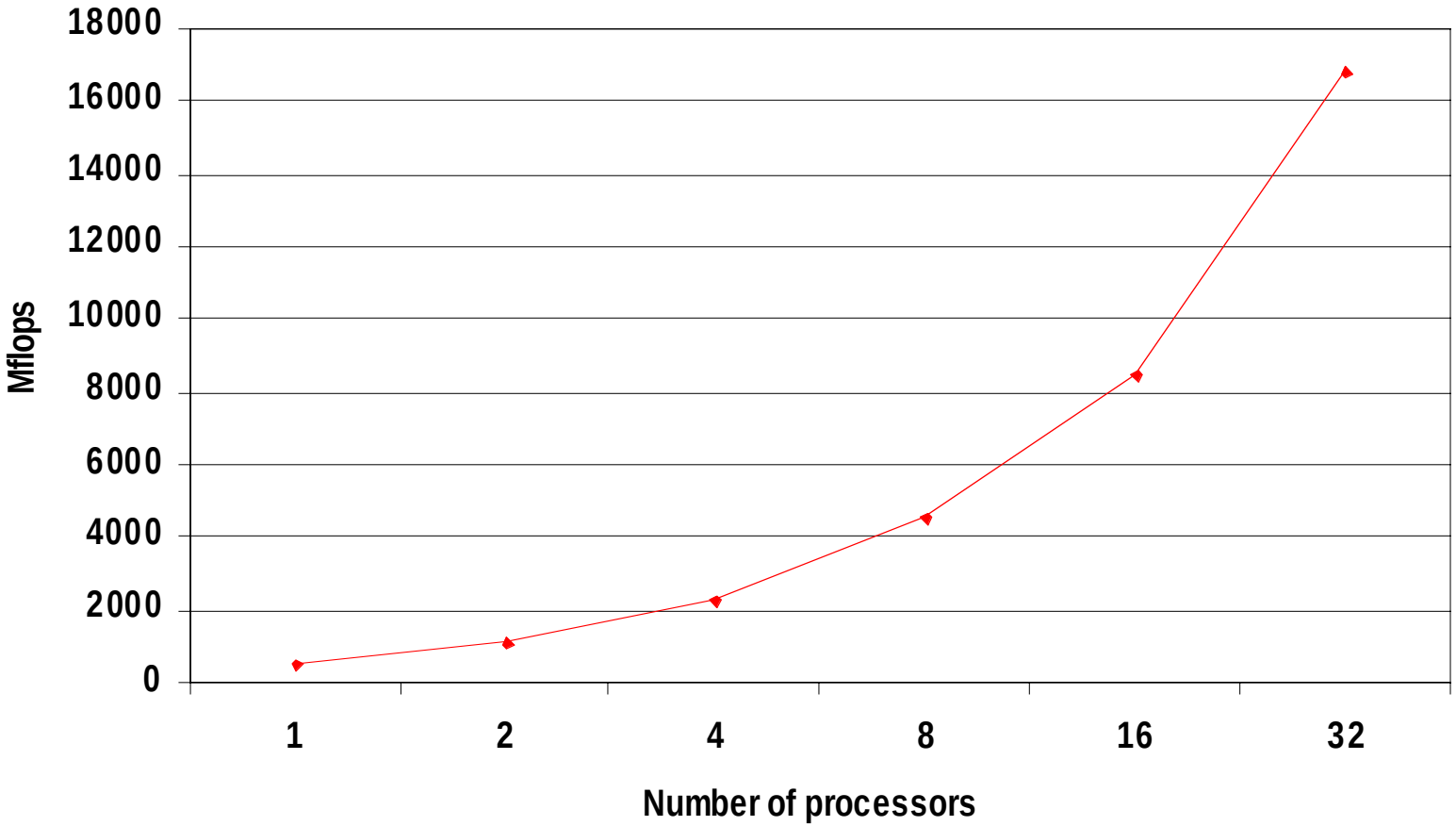


BLAS Performance



BLAS Performance

DGEMM Parallel Performance



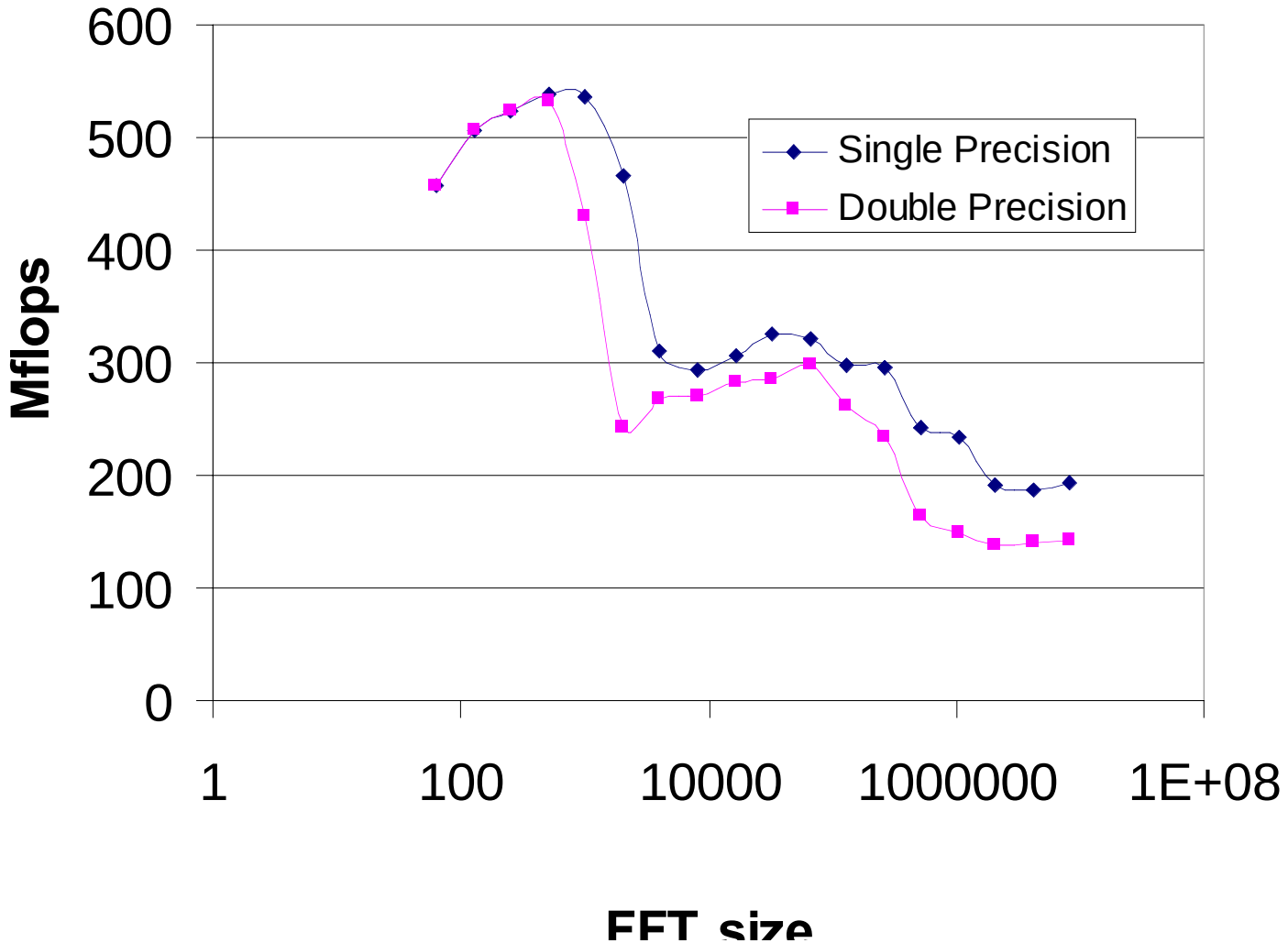
Fast Fourier Transforms (FFT)

- 1-Dimensional FFT applications:
  - Seismic: many short FFTs (1024-4096 data points)
  - Sonar, radar cross-section, speech recognition and astronomical systems: large 1D FFTs
- Multi-dimensional FFTs:
  - image processing
  - PDEs from CFP applications

Following charts show "effective megaflop rate" based on 5n*log(n) for each complex-to-complex FFT.

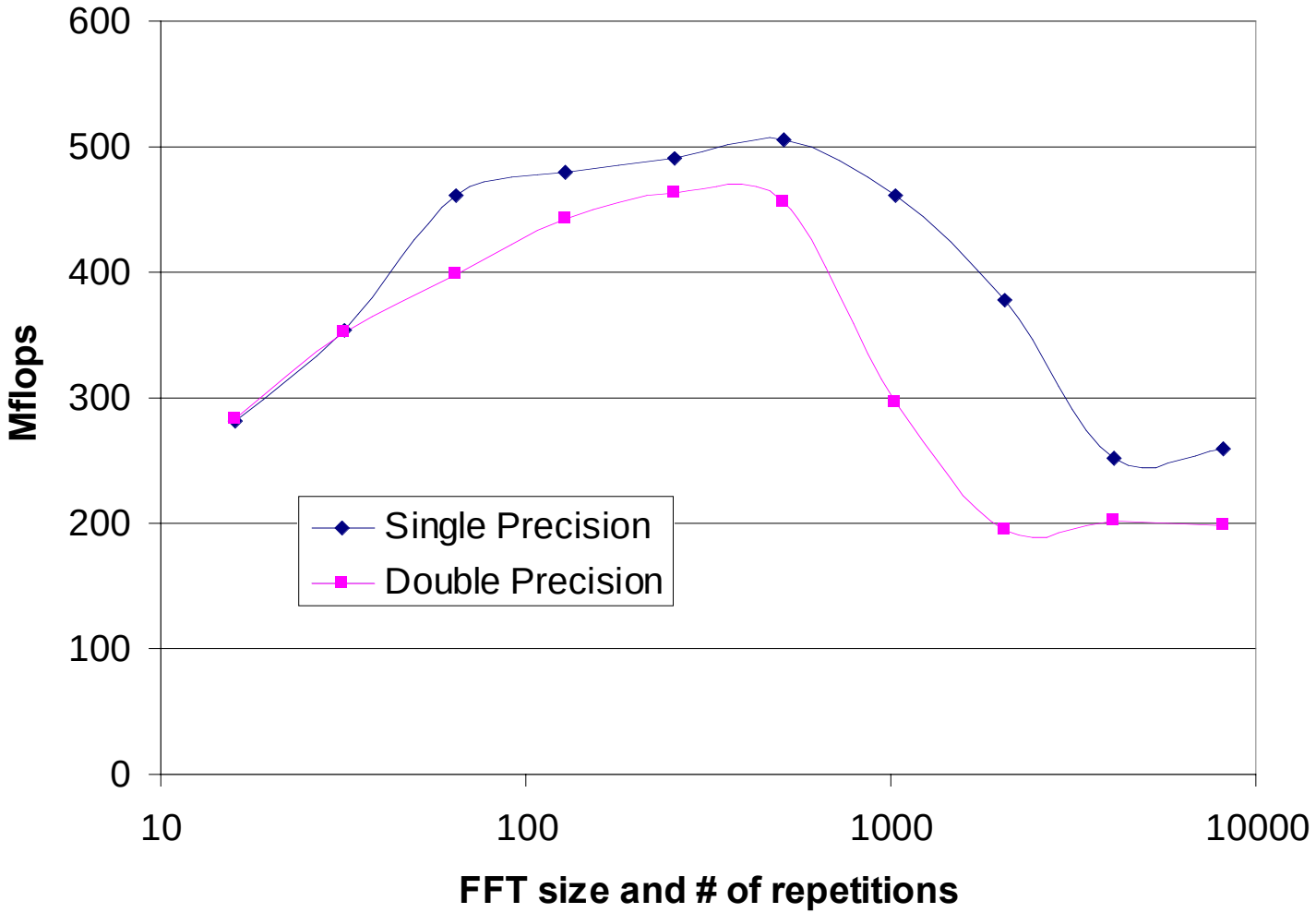
FFT performance

1D Complex-complex FFT



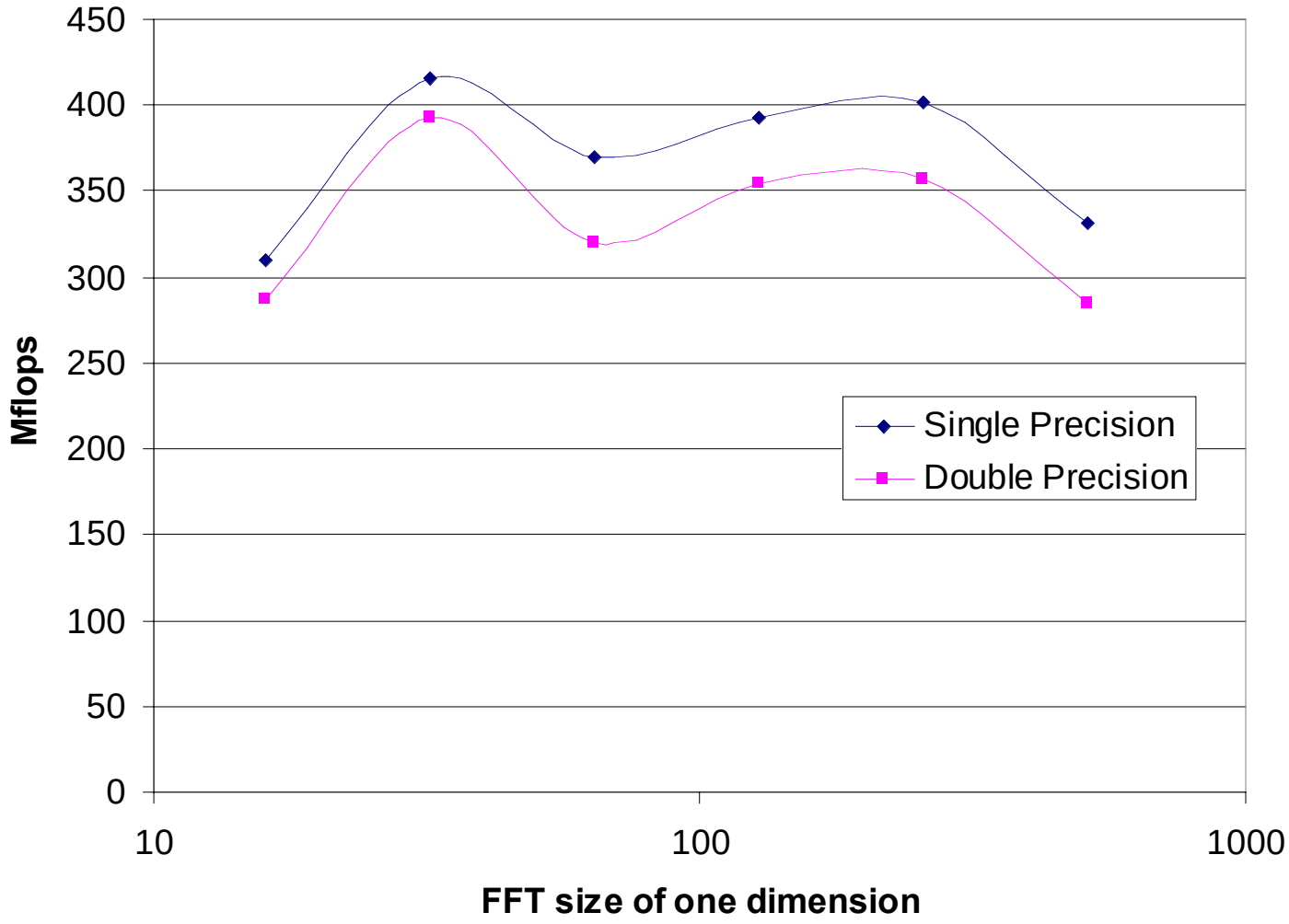
FFT performance

Complex-complex Multiple 1D FFT



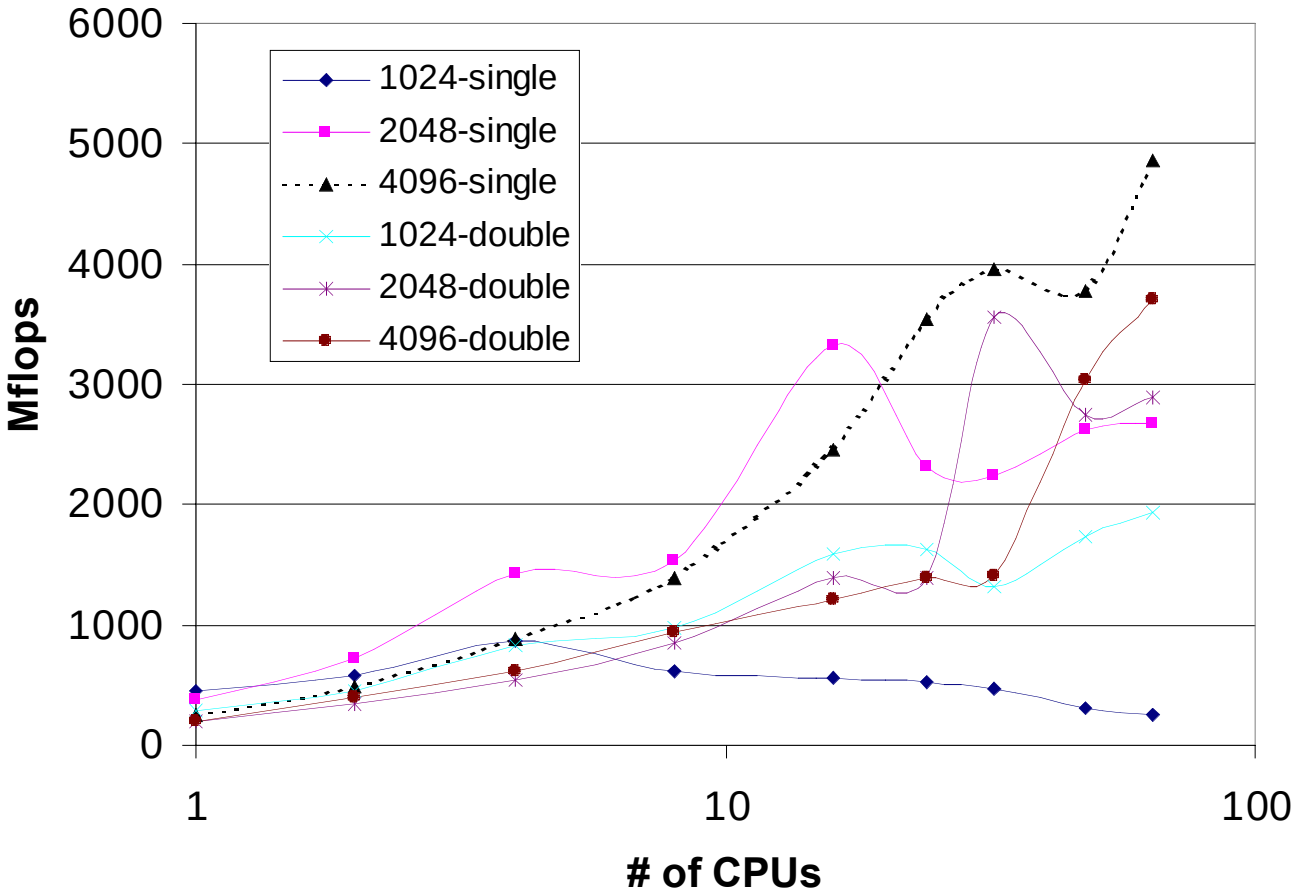
FFT performance

2D Complex-complex FFT



FFT parallel performance

Complex-complex Multiple 1D FFT



"1024-single" means 1024 copies of a size 1024 single precision (32 bits) FFT

Changes to SGI Sparse Solvers

- New Matrix Ordering Options
  - Methods 3 and 4 are termed “Extreme2” ordering
- New default for ordering option
  - Extreme ordering (Method 2) is now the default
- Out-of-core solver option
  - Was in recent SCSL version, but now is documented
  - Single-processor only
  - Striped file system useful
  - Simple interface and performs well

New ordering options

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3. Multiple Nested Dissection orders

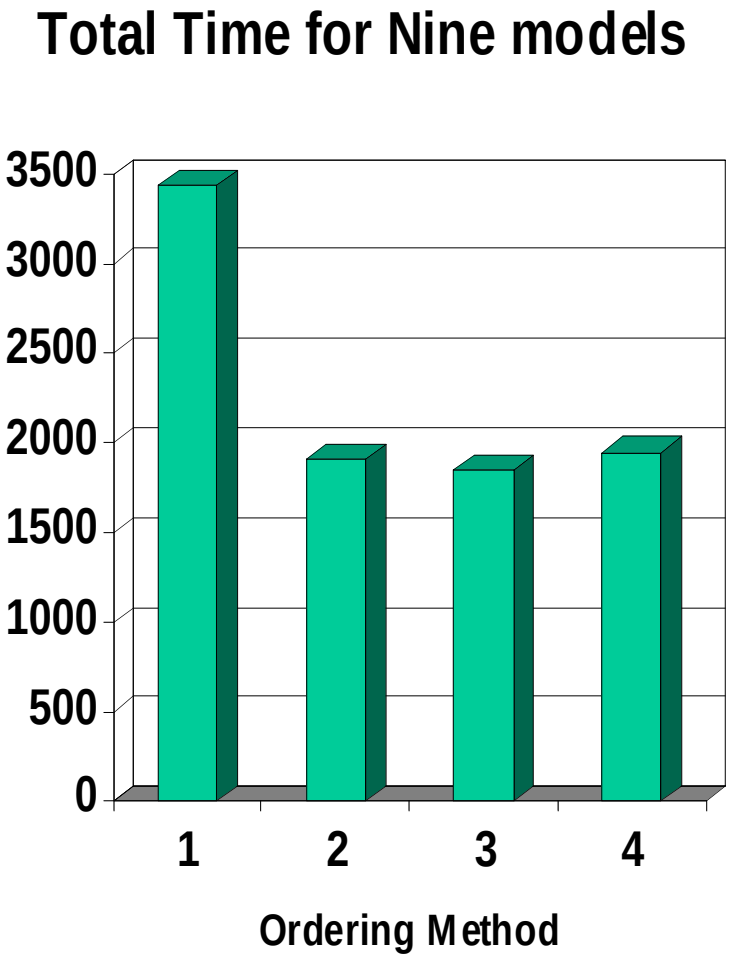
- default is OMP_NUM_THREADS orders
- repeatable quality

4. Multiple ND orders using feedback file information

- default is 2 x OMP_NUM_THREADS orders
- feedback file is at most 5KB, up to 200 records
- binary feedback file
- a solver that learns

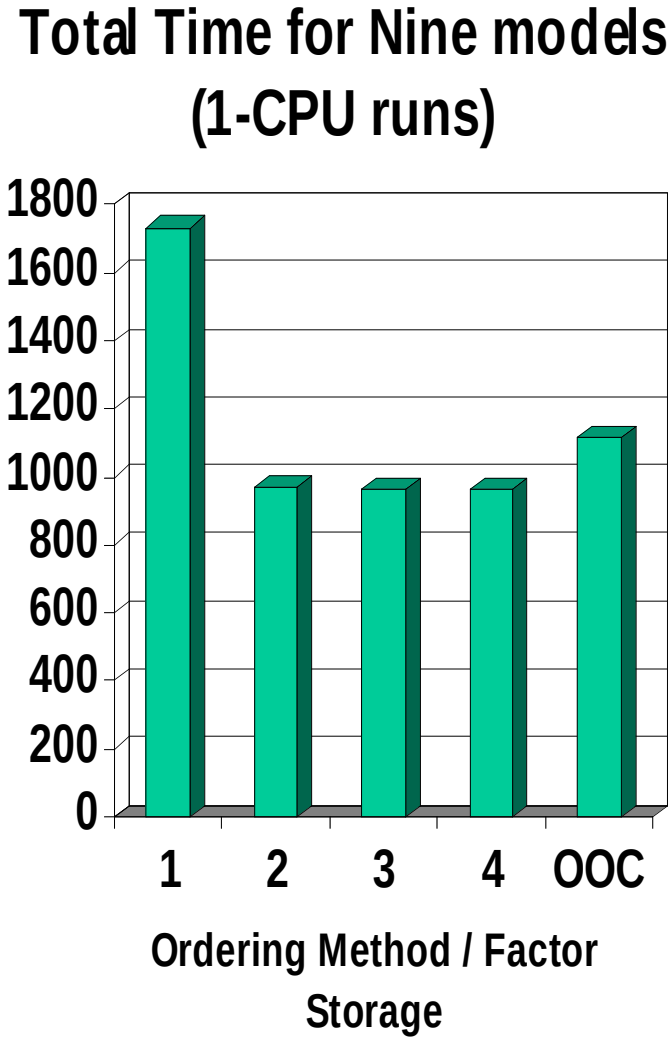
Choosing a default method

- Should default be best for which size model?
- Decided to optimize for medium or larger problems (at least 5000 equations)
- Extreme2 (3) about 3% faster than Extreme, but is new tech., so we use Method 2 as the new default.



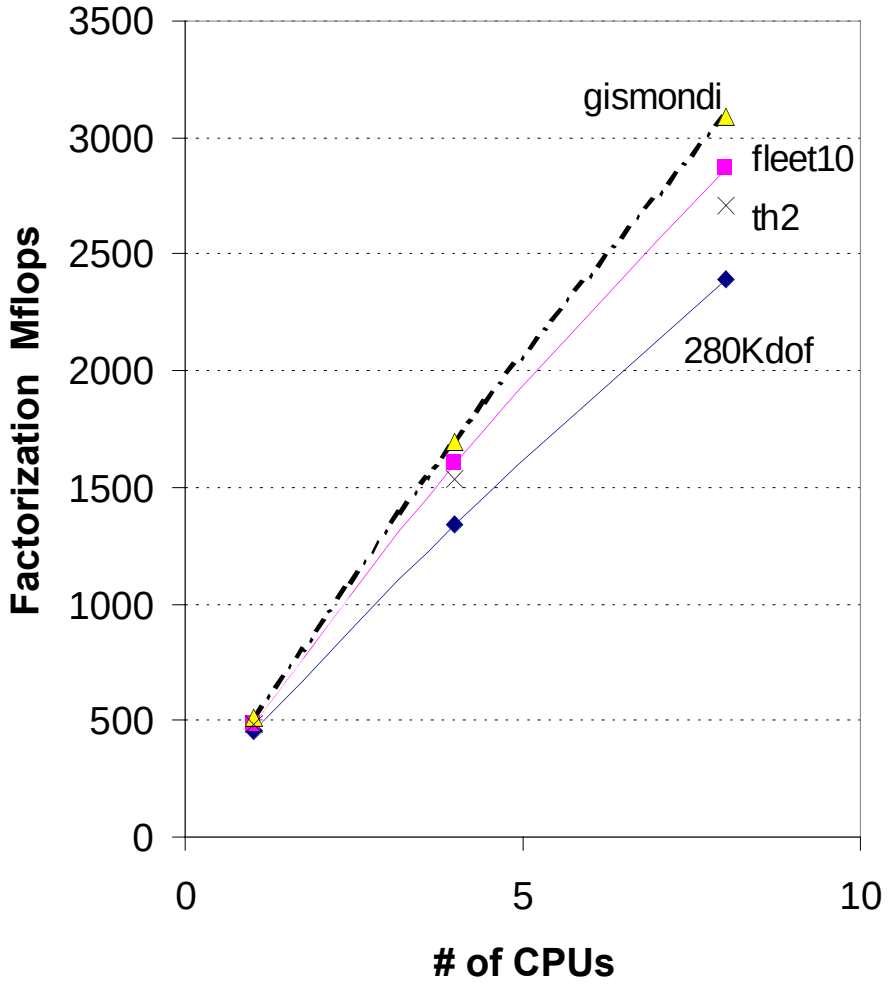
Out-of-core (OOC) Option

- Performance 10–40% slower than extreme (Method 2) ordering in-core; 15% in this case.
- but faster than AMF (1)
- This used 4-way striping on file system -- 140 MB/s on some reads
- Allowed 128MB in-core for factor storage



Scalability: Factorization Mflops

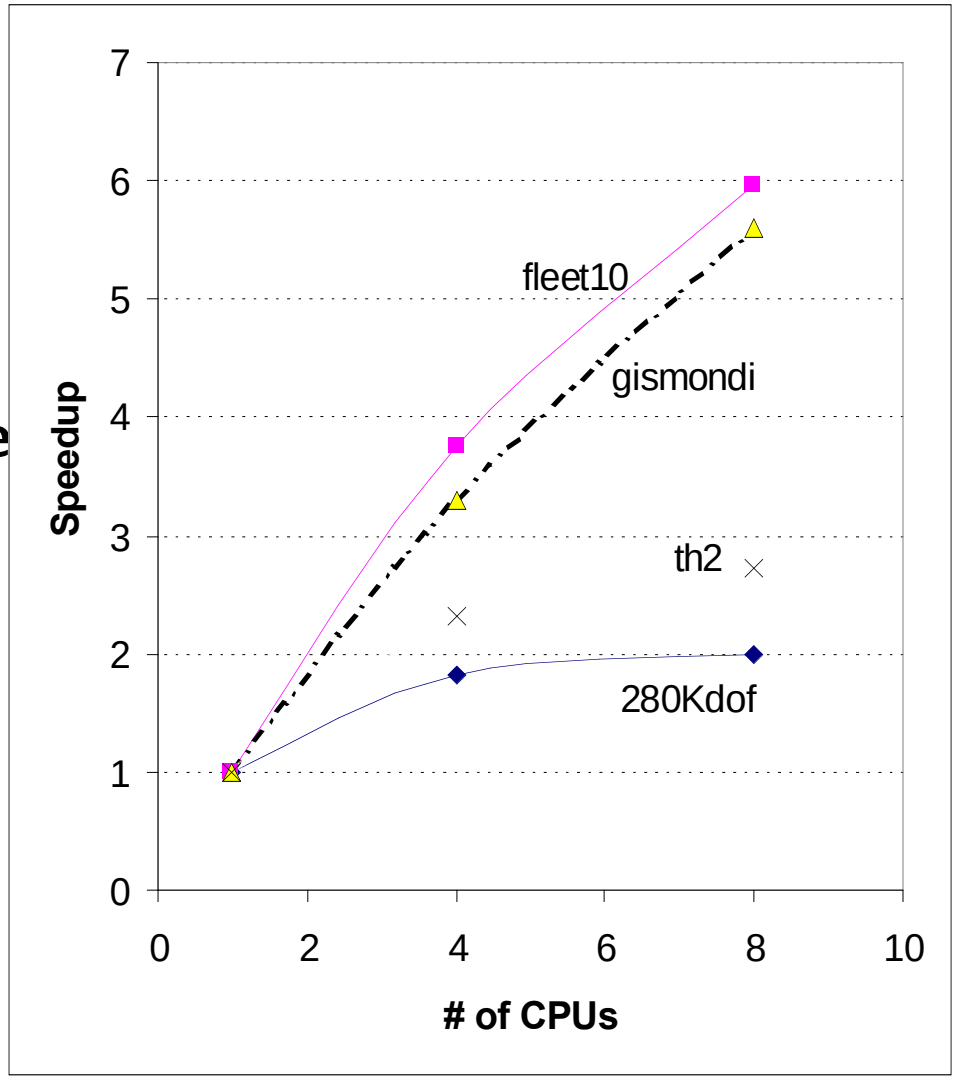
- Amdahl's law resp. for much of lack of scaling in previous chart
- Over 11 Gflops achieved on gismondi on 48 CPUs
- More can be done to improve memory placement
- These results used DSM_ROUND_ROBIN data placement



PSLDLT: Scalability to 8 CPUs

- Measured: Elapsed time for 1 preprocess, 2 factorizations, 2 solves.
- # floating point ops to factor & preprocess time :

	Gflop	secs.
fleet10	383	27
gismondi	133	3
th2	34	18
280Kdof	18	15



Summary

- SCSL 1.2 improvements:
  - FFTs have new interface
  - Add the missing complib Signal Processing functionality.
  - Provide C language interfaces for the Signal Processing routines.
  - Enhance the ordering techniques in the sparse linear solvers.
  - Performance tuning for the MIPS R12000 Processor.
  - Rollup bug fixes from SCSL 1.1 and complib 3.1.
- Comments, questions:
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