Benchmarking CPU Performance

- Many benchmarks available
- MHz (cycle speed of processor)
- MIPS (million instructions per second)
- Peak FLOPS
- Whetstone
  - Stresses unoptimized scalar performance, since it is designed to defeat any effort to find concurrency.
  - Popular way to estimate MIPSMFLOPS (million floating point operations per second)

Benchmarking CPU Performance

- SPEC benchmarks (SPECint, SPECfloat, SPECmark)
  - Maintained by a consortium of workstation vendors
  - Frequently-changing collection of programs one might run on a workstation, plus kernels like matrix multiplication
  - It is virtually impossible to track SPEC performance from one year to the next since the definition of the problem set is always changing
- LINPACK - dense linear solver with partial pivoting
  - 100x100, 1000x1000 or larger

Benchmarking CPU Performance

- NAS parallel benchmark (NPB) - a small set of programs designed to help evaluate the performance of parallel supercomputers.
- Derived from computational fluid dynamics (CFD) applications
- Consist of five kernels and three pseudo-applications in three sizes called Sample Code, Class A and Class B
  - Embarrassingly parallel EP
  - Multigrid MG
  - Conjugate gradient CG
  - D FFT PDE FT
  - Integer sort IS
  - LU solver LU
  - Pentadiagonal solver SP
  - Block tridiagonal solver BT

Benchmarking CPU Performance

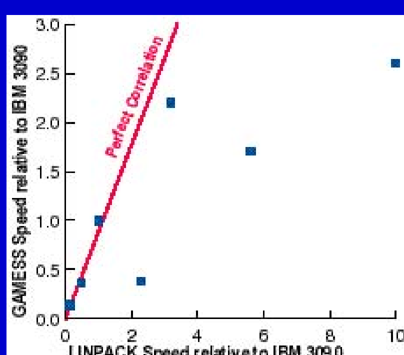
- STREAM, peak memory bandwidth
  - small collection of very simple loop operations
  - tries to estimate the total rate at which all addressable memory spaces can deliver data to respective processors
- **Fhourstones, Dhrystone, nsieve, heapsort, Hanoi, queens, flops, fft, mm**
  - assorted integer and floating-point benchmarks for small problems

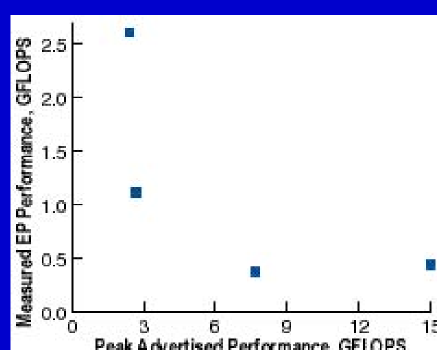
Problems with Benchmarks

- Benchmark performance does not necessarily correlate with application performance
- Performance on two benchmarks may not correlate
- Benchmarks problems tend to be small, easily portable and easy to explain
- As speed increases the benchmarks run too quickly and must be redefined
- Benchmarks tend to measure performance for a particular size of problem

Correlation Examples

- LINPACK v GAMESS computational chemistry application
- Peak FLOPS v FLOPS from NAS benchmark 1
- Correlation is -0.692





HINT - an attempted synthesis

- HINT benchmark created in 1995 at Ames DOE Laboratory by John L. Gustafson and Quinn Snell
- Problem with previous benchmarks - tended to emphasize one part of performance curve
- HINT - Hierarchical INTegration tries to produce curve rather than number
- Aim: to provide a scalable benchmark that reflects the type of work done in iterative refinement

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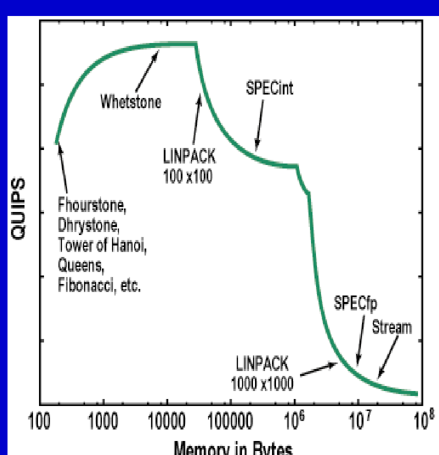
HINT -relation to previous benchmarks



- Hint shows the effects of cache size, and memory size
- Corresponds to
  - Fhourstone etc initially
  - LINPACK 100x100
  - SPECint around 100K
- Eventually corresponds to Stream - a benchmark for memory performance when end up using Virtual Memory

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HINT

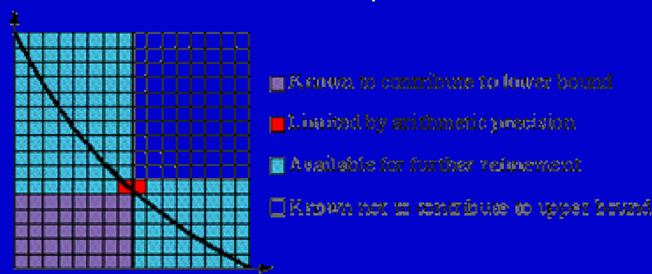
- Infinitely scalable
- Speed defined by quality improvement per second (QUIPS). "Quality" is the reciprocal of the error, which combines precision loss and discretization error.
- The problem can be run with any data type: floating point (any precision), integer (any precision), extended-precision arithmetic, etc
- HINT provides a graph of performance, it also has a "single number" measure (the area under the graph) that summarizes performance
- As the size of the HINT task grows, the memory access pattern becomes more complicated in a way that defeats caches.

Hint Algorithm

- Use interval subdivision to find rational bounds on the area in the xy plane for which x ranges from 0 to 1 and y ranges from 0 to (1- x) / (1+ x).
- Subdivide x and y ranges into 2^k equal subintervals and count the squares thus defined that are completely inside the area (lower bound) or completely contain the area (upper bound).
- The function (1- x) / (1+ x) is monotone decreasing, so the upper bound comes from the left function value and the lower bound from the right function value on any subinterval.
- No other knowledge about the function may be used.

HINT - first subdivision

- Bounds after subdivision into two intervals
- Upper left and lower right contain 87 and 47 squares
- 87-square region should be subdivided
- 47-square error will then move to the front of the queue of subintervals to be split



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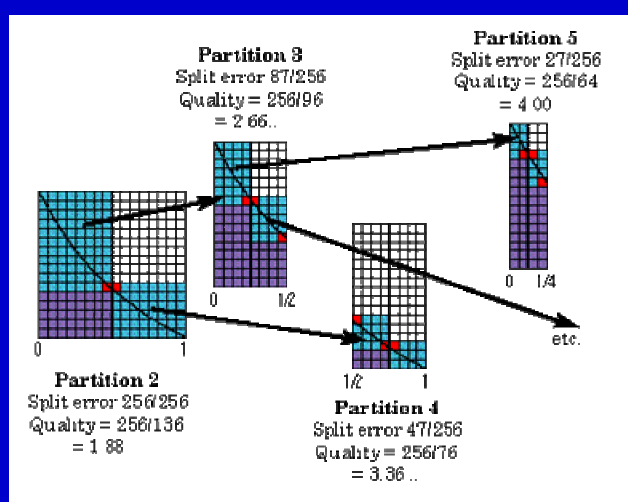
HINT Illustration



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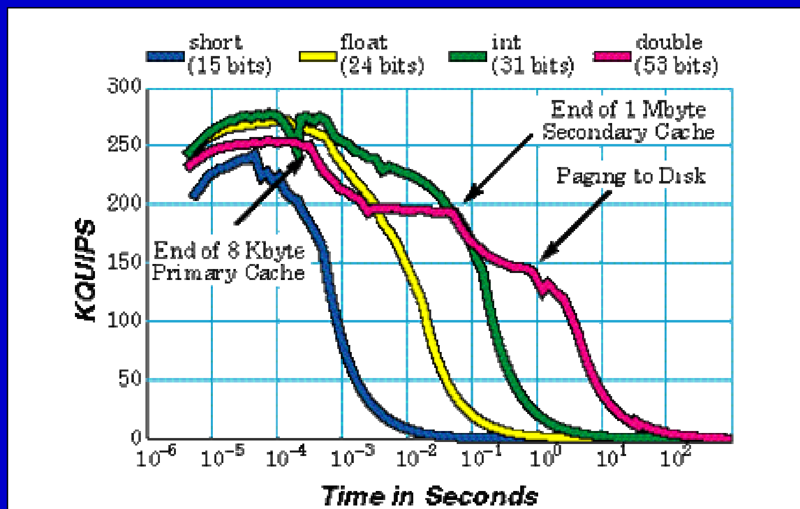
Different Precisions



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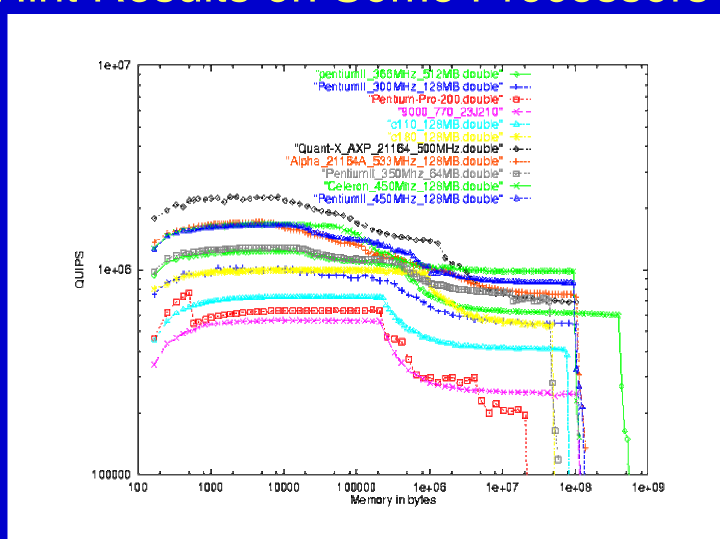
Hint Results on Some Processors



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Recent Results - Machines

- Strider
  - AMD Athlon(tm) MP 2100+ (1733.41 Mhz)
  - 256KB cache each, 3 GB of memory. **Memory bus speed**
- Rc1, v1 (RocketCalc nodes)
  - Intel Pentium Xeon 2.4 GHz, 512 KB cache
  - 8 GB Registered ECC DDR SDRAM per processor
- Arakis
  - Intel Pentium 4 2.4Ghz. 512KB cache
  - Asus P4T533-C motherboard, 850E BIOS, 533/400 MHz FSB, 1GB RDRAM
- Frodo
  - Intel Pentium 4 1.5GHz, 256KB cache
  - RDRAM
- Fianna25
  - Intel Pentium III/450 MHz, 512 KB cache, 256MB PC100 Compliant SDRAM

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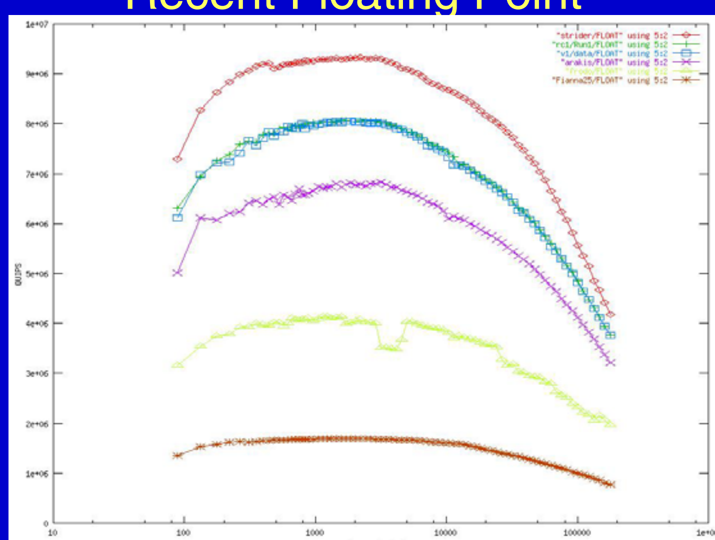
Recent Floating Point



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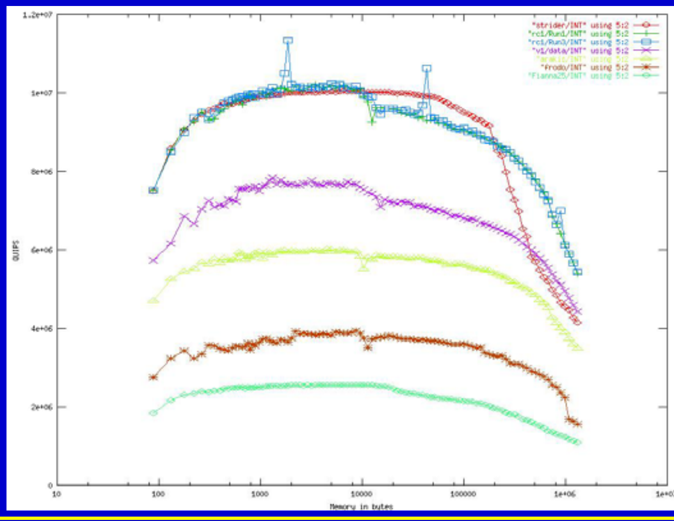
Recent Integer



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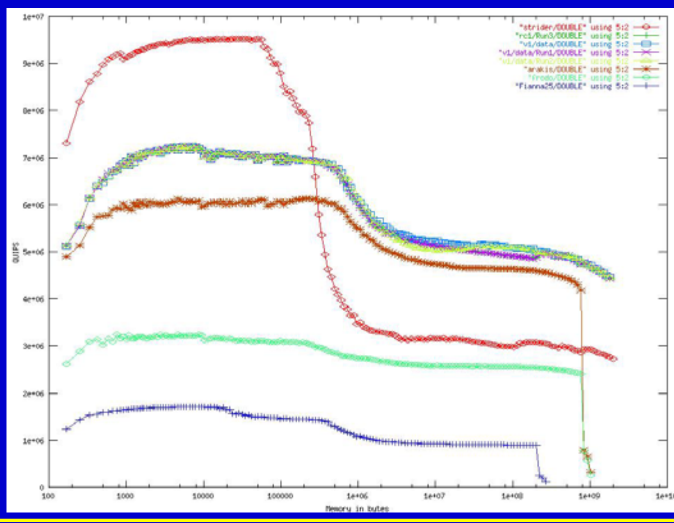
Recent Double Precision



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References

- http://discov.cs.kent.edu/resources/perf/hint/Publications
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