12 Ways to Fool the Masses: Fast Forward to 2011

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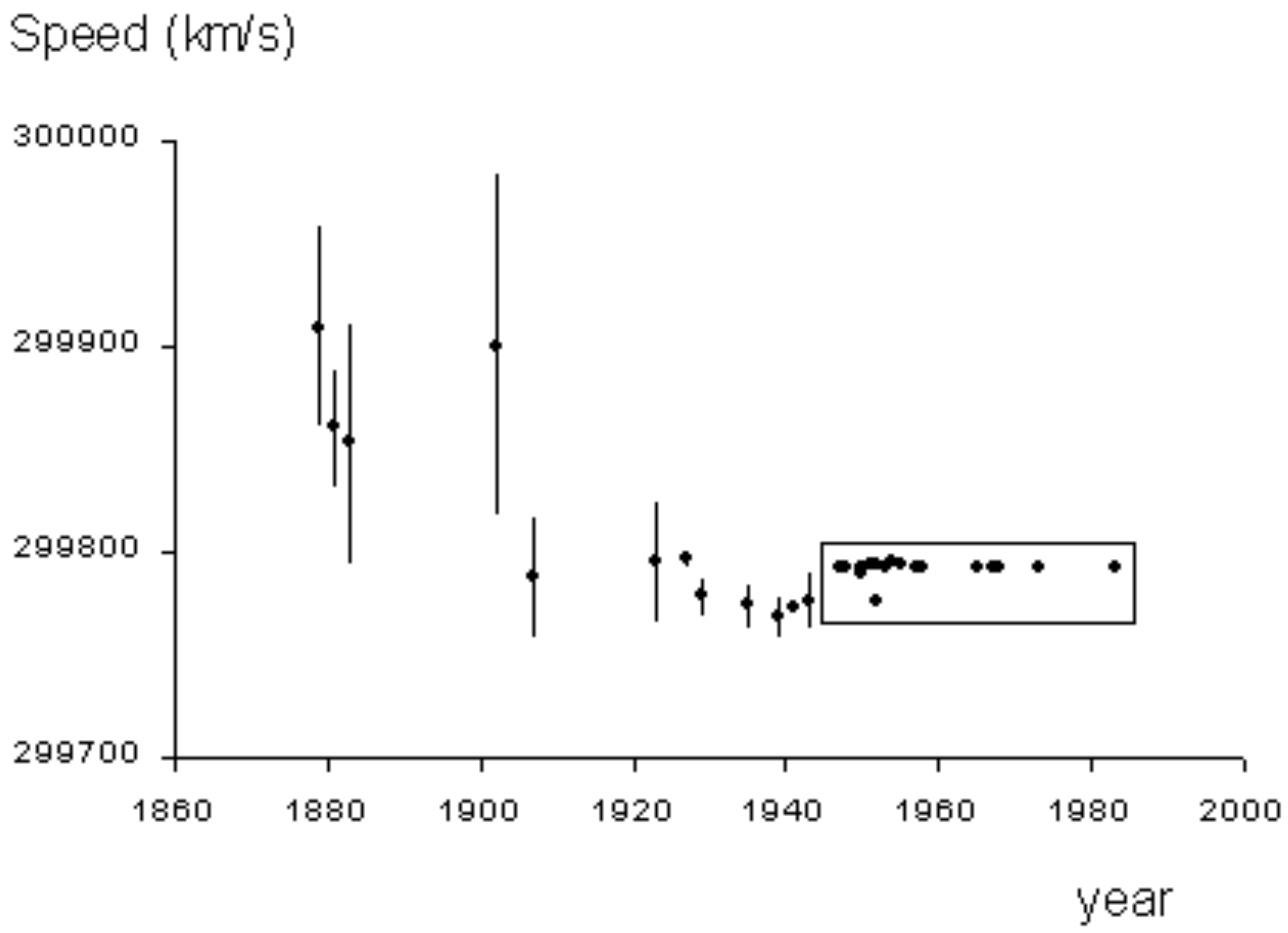
Example from Physics: Measurements of Speed of Light



Why the discrepancy between pre-1945 and post-1945 values? Probably due to biases and sloppy experimental methods.

Example from Psychology: The “Blank Slate”

The “blank slate” paradigm (1920-1975):

- The human mind at birth is a “blank slate.”
- Heredity and biology play no significant role in human psychology – all personality and behavioral traits are socially constructed.

Current consensus, based on latest research:

- Humans at birth universally possess sophisticated facilities for social interaction, language acquisition, pattern recognition, navigation, etc.
- Heredity, evolution and biology are major factors in human personality -- some personality traits are more than 50% heritable.

How did the early 20th century scientists get it so wrong?

- Sloppy experimental methodology and analysis.
- Pervasive wishful thinking and “politically correct” biases.

Ref: Steven Pinker, *The Blank Slate: The Modern Denial of Human Nature*

Example from Anthropology: The "Noble Savage"

Anthropologists, beginning with Margaret Mead in the 1930s, painted an idyllic picture of primitive societies (e.g., Pacific Islanders):

- Virtually no violence, jealousy or warfare.
- Happy, uninhibited – few of the psychological or social problems that afflict much of Western society.

Beginning in the 1970s, a new generation of anthropologists revisited these societies and did more careful studies. They found:

- Crime rates higher than most U.S. and European cities.
- Death rates from inter-tribe conflicts typically exceeding those of warfare among Western nations by factors of 10 or more.
- Complex, jealous taboos surrounding courtship and marriage:
  - Violent reprisals were condoned in cases of adultery or non-virgin brides.
  - Ornamentation worn by males of one tribe, earlier thought to be signs of male-female role reversal, were actually honor badges from warfare.

Conclusion: Some advantages, but hardly the Garden of Eden as earlier depicted.

Why so many errors? "Anthropological malpractice" – Pinker.

Lessons From History

- Research must be based on solid empirical tests and careful, objective analysis of data.
- Researchers must be willing to provide all details of the experimental environment, so others can reproduce their results.
- Rigorous peer review is essential.
- Good intentions or “politically correct” conclusions are no excuses for poor scholarship.
- Erudite technical terminology and mathematical formulas are no substitutes for sound reasoning.
- Hype has no place in the scientific enterprise.
- High standards of honesty and rigor must be vigilantly enforced.

History of Parallel Computing

- 1976-1986: Initial research studies and demonstrations.
- 1986-1990: First large-scale systems deployed.
- 1990-1994: Shoddy measurements and questionable performance claims; faults generally ignored.
- 1994-1998: Numerous firms failed; government agencies cut funds.
- 1998-2002: Reassessment.
- 2002-2009: Recovery.
- 2010: 1 Pflop/s (10^{15} floating-point operations per second) demonstrated on a few large scientific computations.
- 2011: Hetergeneous architectures introduced; researchers and government agencies set sights on exascale computing.

Have lessons been learned? Or are we slipping into hype and sloppiness?

Parallel System Performance Practices, circa 1993

- Performance results on small-sized parallel systems were linearly scaled to full-sized systems.
  - Example: 8,192-CPU results were linearly scaled to 65,536-CPU results, simply by multiplying by eight.
  - Rationale: “We can’t afford a full-sized system.”
  - Sometimes this was done without any clear disclosure in the paper or presentation.

Parallel System Performance Practices, circa 1993

- Highly tuned parallel implementations were compared with untuned implementations on other systems.
  - In comparisons of distributed memory systems with vector systems, often little or no effort was made to tune the vector code.
  - This was the case even for comparisons between SIMD parallel systems and vector systems -- here the SIMD code could have been converted rather easily to efficient vector code, but typically this was not done.

Parallel System Performance Practices, circa 1993

- Inefficient algorithms were employed, requiring many more operations, which resulted in artificially high Mflop/s rates.
  - Some scientists employed explicit PDE schemes for applications where implicit schemes were known to be much better.
  - One paper described doing a 3D discrete Fourier transform by direct evaluation of the defining formula, rather than by using a fast Fourier transform (i.e., $8n^2$ operations rather than $5n \log_2 n$, where n is the total number of points).

Parallel System Performance Practices, circa 1993

- Performance rates on 32-bit floating-point data on one system were compared with rates on 64-bit data on another system.
  - Using 32-bit data instead of 64-bit data effectively doubles data bandwidth, thus yielding artificially high performance rates.
  - Some computations can be done safely with 32-bit floating-point arithmetic, but many cannot.
  - In some emerging applications, even 64-bit (15-digit) floating-point arithmetic is not enough – many more digits are required.

Parallel System Performance Practices, circa 1993

- In some cases, performance experiments claimed in published papers *were not actually performed*. Example:
  - Abstract of published paper:

    "The current Connection Machine implementation runs at 300-800 Mflop/s on a full [64K] CM-2, or at the speed of a single processor of a Cray-2 on 1/4 of a CM-2."
  - Excerpt from text:

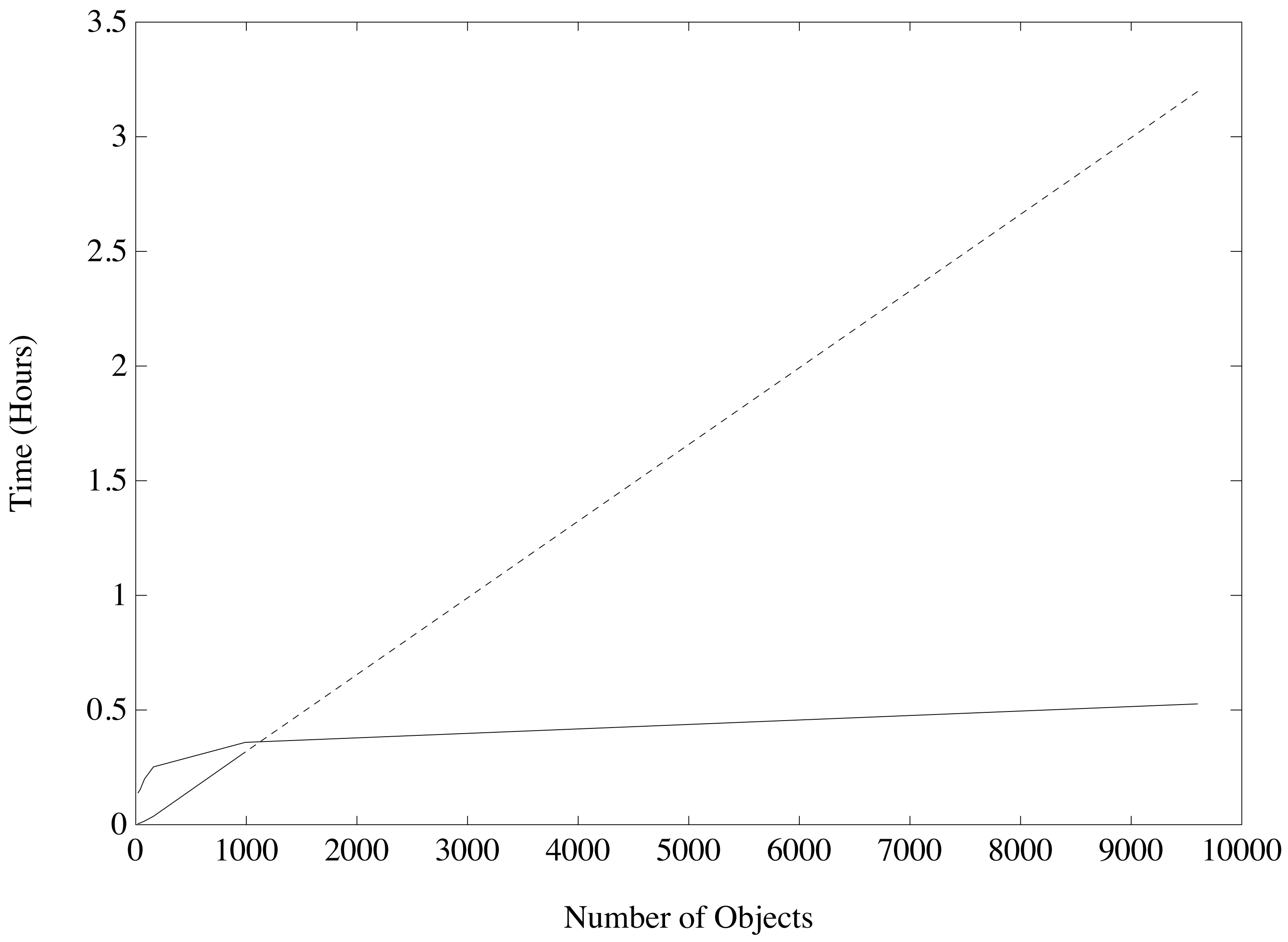
    "This computation requires 568 iterations (taking 272 seconds) on a 16K Connection Machine."

    In other words, the computation was run on a 16K system, not on a 64K system. The figures cited in the abstract were multiplied by four.
  - Another excerpt from text:

    "In contrast, a Convex C210 requires 909 seconds to compute this example. Experience indicates that for a wide range of problems, a C210 is about 1/4 the speed of a single processor Cray-2, …"

    In other words, the comparison computation mentioned in the abstract was not actually run on a Cray-2. Instead, it was run on a Convex system, and a questionable scaling factor was used to produce the Cray-2 rate.

Performance Plot A



Data for Plot A

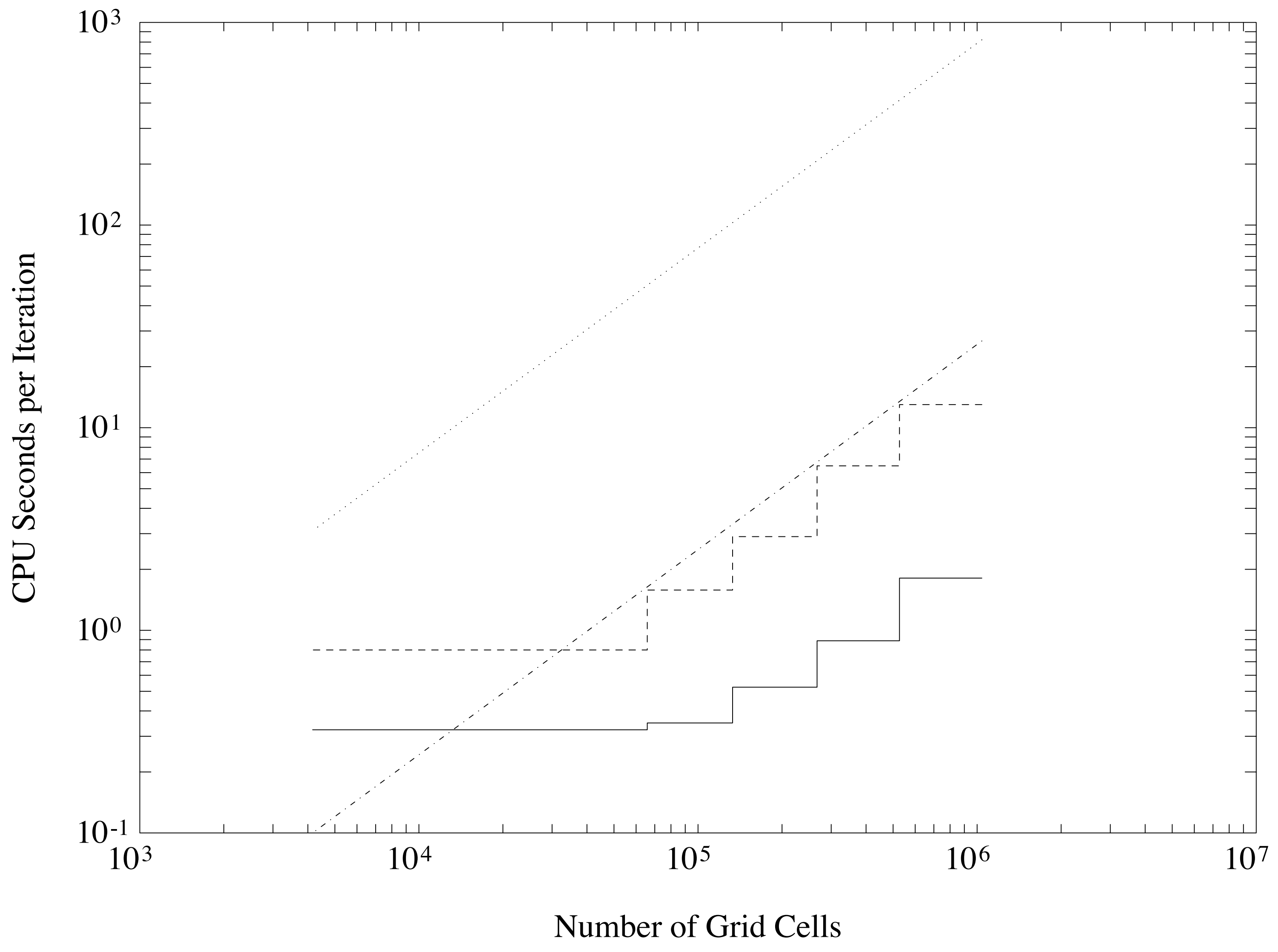
Problem size (*x* axis)	Parallel system run time	Vector system run time
20	8:18	0:16
40	9:11	0:26
80	11:59	0:57
160	15:07	2:11
990	21:32	19:00
9600	31:36	3:11:50*

Details in text of paper:

- In last entry, the 3:11:50 figure is an “estimate.”
- The vector system code is “not optimized.”

Note that the vector system performance is better in each run, except for the last (estimated) entry.

Performance Plot B



Facts for Plot B

- 32-bit performance rates on a parallel system are compared with 64-bit performance on a vector system.
- Parallel system results are linearly extrapolated to a full-sized system from a small system (only 1/8 size).
- The vector version of code is “unvectorized.”
- The vector system “curves” are straight lines – i.e., they are linear extrapolations from a single data point.

Only a handful of the points in these graphs clearly represent real timings.

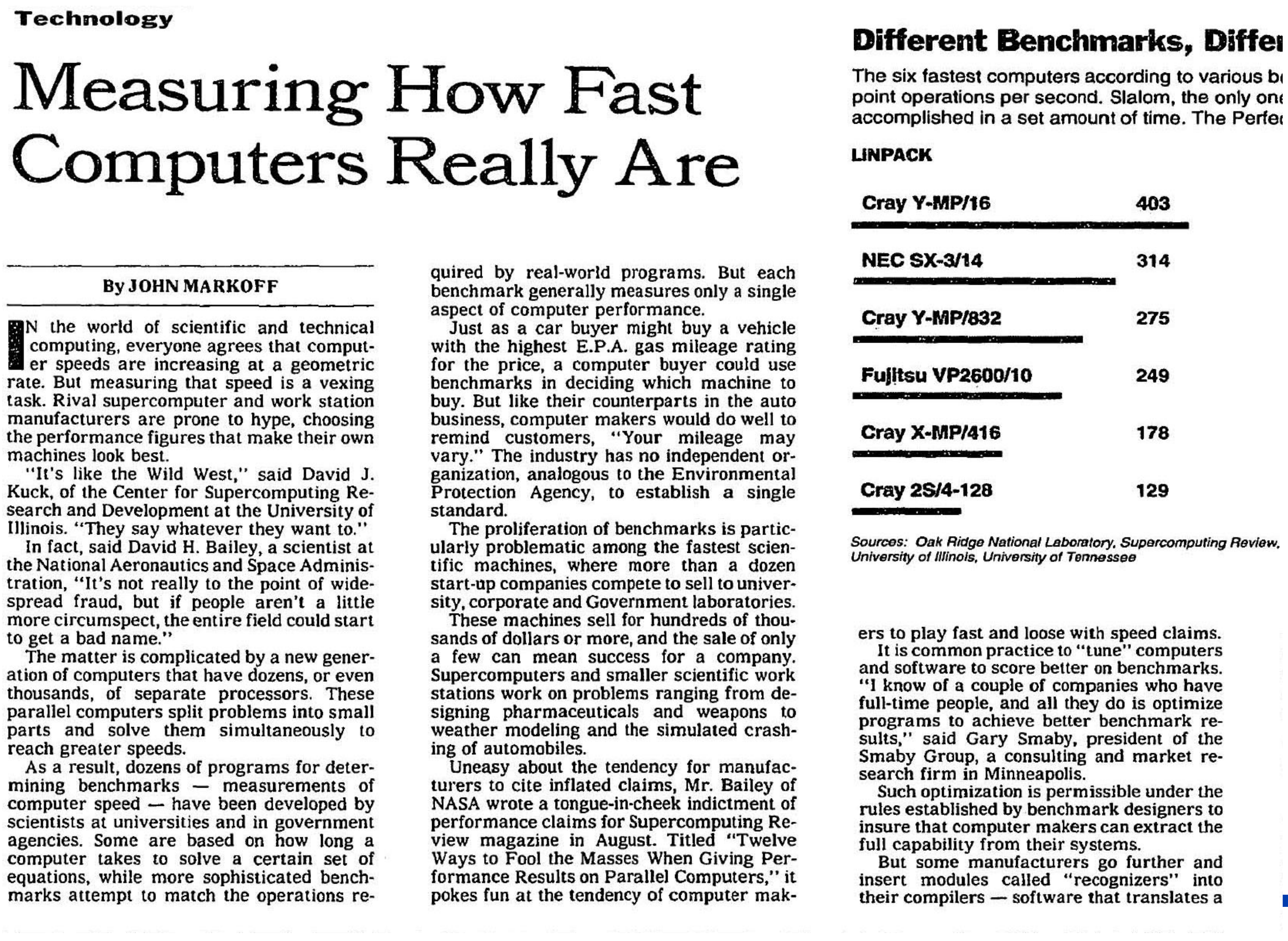
Parallel System Performance Practices, circa 1993

- The examples in my files were written by professional scientists, and most were published in peer-reviewed journals and conference proceedings.
- One example is from an award-winning paper.
- In some cases, researchers accepted free computer time or other benefits from vendors, but did not disclose this fact in their papers.

Twelve Ways to Fool the Masses (1991)

1. Quote only 32-bit performance results, not 64-bit results.
2. Present performance figures for an inner kernel, and then represent these figures as the performance of the entire application.
3. Quietly employ assembly code and other low-level language constructs.
4. Scale up the problem size with the number of processors, but omit any mention of this fact.
5. Quote performance results projected to a full system.
6. Compare your results against scalar, unoptimized code on conventional systems.
7. When direct run time comparisons are required, compare with an old code on an obsolete system.
8. If Mflop/s rates must be quoted, base the operation count on the parallel implementation, not on the best sequential implementation.
9. Quote performance in terms of processor utilization, parallel speedups or Mflop/s per dollar.
10. Mutilate the algorithm used in the parallel implementation to match the architecture.
11. Measure parallel run times on a dedicated system, but measure conventional run times in a busy environment.
12. If all else fails, show pretty pictures and animated videos, and don't talk about performance.

New York Times, 22 Sept 1991



Technology

Measuring How Fast Computers Really Are

By JOHN MARKOFF

IN the world of scientific and technical computing, everyone agrees that computer speeds are increasing at a geometric rate. But measuring that speed is a vexing task. Rival supercomputer and work station manufacturers are prone to hype, choosing the performance figures that make their own machines look best.

"It's like the Wild West," said David J. Kuck, of the Center for Supercomputing Research and Development at the University of Illinois. "They say whatever they want to."

In fact, said David H. Bailey, a scientist at the National Aeronautics and Space Administration, "It's not really to the point of widespread fraud, but if people aren't a little more circumspect, the entire field could start to get a bad name."

The matter is complicated by a new generation of computers that have dozens, or even thousands, of separate processors. These parallel computers split problems into small parts and solve them simultaneously to reach greater speeds.

As a result, dozens of programs for determining benchmarks — measurements of computer speed — have been developed by scientists at universities and in government agencies. Some are based on how long a computer takes to solve a certain set of equations, while more sophisticated benchmarks attempt to match the operations required by real-world programs. But each benchmark generally measures only a single aspect of computer performance.

Just as a car buyer might buy a vehicle with the highest E.P.A. gas mileage rating for the price, a computer buyer could use benchmarks in deciding which machine to buy. But like their counterparts in the auto business, computer makers would do well to remind customers, "Your mileage may vary." The industry has no independent organization, analogous to the Environmental Protection Agency, to establish a single standard.

The proliferation of benchmarks is particularly problematic among the fastest scientific machines, where more than a dozen start-up companies compete to sell to university, corporate and Government laboratories.

These machines sell for hundreds of thousands of dollars or more, and the sale of only a few can mean success for a company. Supercomputers and smaller scientific work stations work on problems ranging from designing pharmaceuticals and weapons to weather modeling and the simulated crashing of automobiles.

Uneasy about the tendency for manufacturers to cite inflated claims, Mr. Bailey of NASA wrote a tongue-in-cheek indictment of performance claims for Supercomputing Review magazine in August. Titled "Twelve Ways to Fool the Masses When Giving Performance Results on Parallel Computers," it pokes fun at the tendency of computer makers to play fast and loose with speed claims.

It is common practice to "tune" computers and software to score better on benchmarks. "I know of a couple of companies who have full-time people, and all they do is optimize programs to achieve better benchmark results," said Gary Smaby, president of the Smaby Group, a consulting and market research firm in Minneapolis.

Such optimization is permissible under the rules established by benchmark designers to insure that computer makers can extract the full capability from their systems.

But some manufacturers go further and insert modules called "recognizers" into their compilers — software that translates a

Different Benchmarks, Differ

The six fastest computers according to various b
point operations per second. Slalom, the only on
accomplished in a set amount of time. The Perfe

LINPACK

Cray Y-MP/16	403
NEC SX-3/14	314
Cray Y-MP/832	275
Fujitsu VP2600/10	249
Cray X-MP/416	178
Cray 2S/4-128	129

Sources: Oak Ridge National Laboratory, Supercomputing Review, University of Illinois, University of Tennessee

Excerpts from NY Times Article

“Rival supercomputer and work station manufacturers are prone to hype, choosing the performance figures that make their own systems look better.”

“It’s not really to the point of widespread fraud, but if people aren’t somewhat more circumspect, it could give the field a bad name.”

Fast Forward to 2011: Five New Ways to Fool the Masses

1. Cite performance rates for a run with only one processor core active in a shared-memory multi-core node. For example, cite performance on 1024 cores, even though the code was run on 1024 nodes, wasting 15 out of 16 cores on each node.
2. Cite performance rates only for a core algorithms (such as FFT or LU decomposition), even though the paper mentions one or more full-scale applications that were done on the system.
3. List only the best performance figure in the paper, even though the run was made numerous times.
4. Employ special hardware, operating system or compiler settings that are not appropriate for real-world usage.
5. Define “scalability” as successful execution on a large number of CPUs, regardless of performance.

Benchmarks Help Prevent Abuse

- Benchmark tests must be well-designed, rigorous and scalable.
- Benchmark codes are problematic, because architectures and languages change, but “reference implementations” are useful.
- Well-thought-out and well-enforced “ground rules” are essential.
- A rational scheme must be provided for calculating performance rates.
- Tests must be specified to validate the correctness of the results.
- A repository of results must be maintained.

Examples:

- The NAS Parallel Benchmarks (still useful, but a bit dated).
- The LBNL-UCB “Torch” Reference Kernels (also known as the “Dwarfs” or “Motifs”). See:
  http://crd.lbl.gov/~dhbailey/dhbpapers/dwarfs09_intro.pdf

General Guidelines to Prevent Abuse

- Direct comparisons of run times on real applications are preferred.
- If results are presented for a well-known benchmark, established ground rules must be followed.
- Only actual performance results should be presented, not projections or extrapolations (unless very clearly disclosed and justified).
- Performance figures should be based on comparable levels of tuning.
- Mflop/s, Gflop/s, Tflop/s rates should be computed from operation counts based on the best practical serial algorithms.
- When computing parallel speedup figures, the denominator rate should be based on an efficient single-processor implementation.
- Any ancillary information that would affect the interpretation of the results should be fully disclosed (e.g., the use of 32-bit instead of 64-bit data, etc.).
- Special care should be taken for figures and graphs.
- Whenever possible, full background information should be provided: algorithms, hardware and software configuration, language, compiler flags, tuning, timing method, basis for operation counts, etc.