Is Megahertz Enough?

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INTRODUCTION: WHAT'S THE PROBLEM?

PC buyers usually rely on the clock speed (megahertz) of a PC's microprocessor to determine their purchasing decision. Because the industry lacks a simple, universally accepted way to judge performance, users have become conditioned to substituting clock speed to gauge how fast their applications will run.

This practice has grown common over many years because:

- The popularization of the PC among general consumers has increased the available pool of buyers unfamiliar with factors in PC performance.
- The growth of the direct model of PC purchases has made it more likely that the actual end user will buy a PC for himself or herself without the help of a third party familiar with factors that influence PC performance.
- The increasing sophistication of the PC exposes the buyer to a growing number of often arcane technical specifications, from which clock speed promises a convenient escape.

The clock speed of PC processors has reached over 3,000MHz. This clock speed is 600 times more than the 5MHz of the first PC processors. Despite that advancement in clock speed, applications do not run 600 times faster. The fact that PC performance does not scale directly with clock speed indicates clock speed does not tell PC buyers everything they need to know to gauge PC performance. Since, IDC forecasts, the 135.5 million PCs sold in 2002 will represent an approximately $172 billion industry, an unreliable performance measure influencing such a staggering amount of revenue is a significant problem for both PC buyers and the PC industry.

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IDC OPINION

What does a proper measure of PC performance do? Why shouldn't PC buyers use processor clock speed exclusively?

IDC believes that a proper measure of performance reflects how much work a PC does in a given period of time. That requires knowing how much time the PC worked and how efficiently it worked. Clock speed alone is not a good measure of PC performance because it does not account for performance efficiency. Efficiency is determined by other factors.

Those factors include the processor architecture and how the rest of the PC — the graphics controller, main memory, hard drive, and so on — contributes to the work that gets done. Since a PC has many components and simultaneous tasks, clock speed only represents one facet of one component and is not enough to measure the real performance of the entire system.

WHAT HAPPENED TO CLOCK SPEED?

At the start of the PC industry, PC buyers used clock speed to gauge performance because different PC processors were on par in efficiency. Part of IBM's decision to use x86 processors for the original IBM PC was to ensure multiple sources of compatible components. In ensuring x86 compatibility, processor vendors developed processors that were similar in their internal designs, or architectures. As a result, clock speed became the distinguishing characteristic of the PC processor.

The situation changed, however, in the middle and late 1980s as the PC began to serve a greater variety of tasks and applications. More than word processors, PCs became drawing tools, entertainment appliances, and communication devices. They also began going outside the office and into homes, on the road, and into the back office where only mainframes and mini-computers used to reside. From the increasingly varied uses and locales evolved a greater number of user profiles, or usage models, with special requirements for PCs to fulfill.

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Accordingly, processor designs evolved, but not merely by scaling the clock speed. In October 1985, for example, Intel introduced the 80386 processor, which doubled the amount of transistors in the prior generation's 80286 processor and introduced 32-bit computing to the PC. These advances were far more beneficial to PC performance than the advance from the 80286's 12MHz to the 80386's 16MHz. Advances that took place in subsequent designs made the processor's job easier by integrating small memory caches that stored the data closer to the processor core. Designers also improved efficiency by integrating other components, such as float-

ing point units, and introduced more efficient techniques of data processing, including adding more processing lines (pipelines) and processing data and instructions to run the critical tasks first. Designers also found ways to make processors work better in the context of the entire system by introducing new instructions (e.g., MMX™ and 3DNow!™ Professional for multimedia) that were optimized for richer data processing and by giving the processor a faster front-side bus to the rest of the system.

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Due to the different requirements of specific form factors and segments, different processors from even the same vendor began to deliver varied performance at the same clock rate. The issue became more apparent when vendors like AMD moved to develop their own architectures that, while still compatible with the x86 instruction set, took different approaches to maximize performance. These approaches included changes that impacted both the processor and the system (e.g., improved front-side buses).

WHY HAVEN'T WE REPLACED CLOCK SPEED YET?

IDC believes that, despite the increasingly visible awareness within the industry of the inadequacies of clock speed, PC buyers continue to use it because there are no adequate industrywide metrics available. They like clock speed because it is simple — the perception is that a higher number means better performance — and universally understood. For its part, the PC industry struggles against the sheer difficulty of replacing such an entrenched measurement. One attempt to supply a new measurement, the PR Rating introduced in 1996, failed because it never achieved widespread acceptance. At the same time it lost credibility with PC buyers because it was confusing and didn't reflect individual usage models, it also lost credibility in the industry because each vendor assigned the rating itself without third-party verification and without full disclosure about the details of the underlying tests. As a result, the PR Rating never had the weight of the entire industry behind it.

However, we also believe that new forces of change are emerging. These include:

- Increasing recognition that performance does not scale directly with clock speed
- Mounting disparity of underlying architectures and clock speeds —of processors from the same vendor and from different vendors — that defy easy comparison
- Acknowledgement that other components, such as graphics processors and memory, could have as much impact on overall PC performance as processor speed
- Rise of other factors in the overall PC purchase decision, such as cost, features, upgradeability, portability, battery life, and connectivity

- Within a given architecture, scaling clock speed alone will reach diminishing returns. Also, measures to counteract transistor current leakage, energy consumption, and heat output are increasing the system cost.
- Processors comparable in performance to processors with higher clock speeds not valued equally

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Processor vendors increasingly reflect the need for a more balanced approach in the way they convey performance. AMD now names its AMD Athlon™ XP processors with model numbers that indicate the performance of each processor relative to other AMD Athlon XP processors and the prior AMD Athlon family of processors. The company adopted model numbers to discourage megahertz-to-megahertz comparisons. Motorola, supported by its system partner Apple, has historically tried to balance clock speed and efficiency in its PowerPC processors through a number of architectural innovations, including its Altivec technology for multimedia processing and the use of multiple levels of cache. Even Intel, the leading proponent of megahertz, has long used architectural innovation (such as advances in front-side bus speed) to improve the efficiency of its processors. Intel also is raising public awareness by pouring substantial resources into its upcoming mobile processor, code-named Banias, which will operate at lower clock speeds than the current Pentium® 4 processors. Intel will market the processors on factors like long battery life, small size, low weight, and wireless connectivity, features for which clock speed cannot be the sole measure. The need for a more balanced approach to performance will grow as future processor and system architectures continue to diverge. For example, Transmeta's upcoming 256-bit VLIW processor, code-named Astro, will break further away from the industry's standard processor architecture and the AMD Athlon™ 64 processor, with an integrated memory controller, will innovate further away from the industry's standard partitioning.

CHALLENGES TO INDUSTRY

Changing this situation will be a significant challenge for the industry because the standards are very high.

While the PC industry's products have evolved, its performance measures have not. As a result, the industry has lost the ability to communicate product performance effectively. Changing this situation will be a significant challenge for the industry because the standards are very high. IDC believes that the PC industry owes buyers a new measure that is:

- System based. PC performance is about the whole system of interdependent components, not just the processor.
- Simple. Any new measure must be as easy to understand as clock speed.
- Flexible. Novices should be able to look at just one or a few numbers. Advanced users, however, should be able to go deeper into their research on PC performance, should they choose.
- Tailored to usage models. In order to be useful and relevant to buyers, a measure must reflect how a PC will be used.

- Built around clock speed and efficiency for delivered application performance. Processor and system architectures reflect a series of different design decisions. Designers will continue to rely on both factors to improve application performance.
- Consistent. While underlying tests will evolve to enhance the measure's ability to convey performance, the actual measure presented to PC buyers must remain consistent.
- Repeatable. Allowing for margin of error, the underlying tests run on a PC must give the same or similar results when run again independent of who is doing the testing.
- Transparent. In order to be credible, the underlying tests and the testing methodology must be open to scrutiny.
- Given broad industry support. PC buyers should only accept a single, unified method. It's not acceptable to have competing methods from multiple sources and different backers in each camp.
- Administered by a credible, independent party. All parties involved must trust that all products are being measured fairly and impartially.
- Systematically updated. In order to evolve with changing usage models and configurations, the measure would need to be updated accordingly.

CHALLENGES TO BUYERS

When lacking a true measure of PC performance, all PC buyers should ask prodding questions: What is clock speed not telling me about the processor's and the system's performance? Isn't good PC performance more than just a matter of the processor? With only clock speed to go on, how am I supposed to gauge how fast my applications will run?

PC buyers of all kinds must insist on industry action. When buying a PC, consumers should demand an indicator of how a certain PC is suitable to run their applications and meets their individual needs. To ensure a higher return on investment, corporate and commercial buyers should insist that their requests-for-proposals account for more than frequency when evaluating performance. When lacking a true measure of PC performance, all PC buyers should ask prodding questions: What is clock speed not telling me about the processor's and the system's performance? Isn't good PC performance more than just a matter of the processor? With only clock speed to go on, how am I supposed to gauge how fast my applications will run?

CONCLUSION

IDC believes that tackling these challenges will benefit the industry by allowing vendors and users to segment the market and help it grow in the future. Traditional scaling is not enough and will not help the industry prosper. Measurements that judge PC performance based on more than traditional scaling will encourage more diverse ways of achieving higher performance. They will also acknowledge that good performance can be many things, such as fast applications, but also long battery life and high frame rate. In the meantime, don't base your buying decision on megahertz alone and, whenever possible, rely on industry benchmarks that will give you a more accurate picture of the performance of the entire system.

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