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Backgrounder

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Moore's Law: Standing the Test of Time

Sept. 22, 2009 — Moore's Law, the key engine driving the semiconductor industry for over 40 years, was recently recognized by industry analyst Dan Hutcheson as "one of the most important economic theories to be developed in the 20th century" and "definitely the most important theory developed in innovation economics."

During his tenure as director of Fairchild Semiconductor's Research and Development laboratories, Dr. Gordon E. Moore documented his observation of a manufacturing trend and economic model in Electronics magazine. He illustrated a semiconductor cost curve revealing the number of components that would be integrated in the most economical chips at given points in time. He stated: "The complexity for minimum component costs has increased at a rate of roughly a factor of two per year."

Moore later changed his observation to a doubling every 2 years and over time this became "Moore's Law," which has since been translated to mean that the number of transistors on a chip doubles roughly every 2 years.

Moore's Law Benefits Continue

The increase in the number of transistors on a microprocessor provides more functions per chip at significantly lower cost per function, resulting in even smaller, higher performance and more energy-efficient computing devices. Multi-core chips are a significant trend enabled by this Moore's Law progress over the past decade. They provide vastly improved performance (especially for parallelizable applications) while keeping power consumption in check.

Additionally, the integration of more and more capabilities and features has became possible over computing history; we've seen math coprocessors, cache memory and integrated memory controllers come off motherboards and integrated into the microprocessor. Soon, Intel Corporation will showcase microprocessors with complete graphics solutions onboard as well.

These processors vastly simplify motherboard design and enable sleek systems for all client segments.

Increasing the number of transistors on a microprocessor also enables the development of highly integrated, low-power and cost-effective System-on-a-Chip (SOC) components for smartphones, mobile Internet devices (MIDs) and embedded applications.

Moore's Law is the driving force behind Intel's "tick-tock" model, a new process technology approximately every 2 years and a new CPU microarchitecture on alternating years, resulting in new products brought to market annually.

The Future of Moore's Law

Intel currently has visibility on how to extend Moore's Law for several more generations. This window of visibility has not changed over the past several decades. Moore's Law's continuation requires innovations in integrated circuit materials and structure, not just dimensional scaling. Strained silicon and high-k/metal gate transistors are good examples of this trend.

Another area that Intel is investigating is the use of compound semiconductors (rather than silicon) in the channel of the transistor. Such materials, also known as III-Vs, show promise of greatly improving transistor performance while reducing power. However, many challenges remain, particularly with integrating on a silicon substrate.

Many other challenges lay ahead, a notable one being lithography. Today, Intel uses light wavelength of 193nm to pattern its chips, even though they have features as small as 30nm. Going forward, Intel and the rest of the industry are looking at a variety of lithography options.

Intel is also researching 3-D Chip Stacking and other ways to integrate for high density chip to chip connections, small form factor and the ability to combine dissimilar technologies.

Summary

Moore's Law will continue to drive the semiconductor industry well into the 21st century. Intel is the industry leader in bringing innovations from research to manufacturing and will continue to be the leader in driving Moore's Law innovation.

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