

**Plenary****Interconnection Limits on XX Century Gigascale Integration (GSI)**

by

James D. Meindl

## Abstract

From the inception of microelectronics in 1959 until the early 1990's, transistors dominated both the performance and cost of microchips while interconnects were of secondary importance. In recent years, this hegemony has largely dissipated. Interconnects have become critical determinants of microchip performance and cost. To appreciate the epical nature of this shift, consider the following illustration of the interconnect problem. For late 1980's 1.0  $\mu\text{m}$  technology, the intrinsic switching delay of an unloaded MOSFET approaches 10 ps while the response time of a 1.0 mm interconnect is approximately 1 ns. But, for early 2000's 0.1  $\mu\text{m}$  technology, the intrinsic delay of a MOSFET decreases to about 1.0 ps while the response time of a 1.0 mm interconnect increases to 100 ns. The latency of a 1.0 mm interconnect devolves from one decade faster to two decades slower than transistor delay. Concurrent with this signal wiring dilemma, clock frequency is increasing by 100X placing stringent new demands on the interconnects that implement the chip clock distribution network. Supply current is increasing by 60X while supply voltage scales downward by 5X thereby imposing a huge new burden on the interconnects that implement the power distribution network. Maximum total wire length per chip increases by 50X. And, chip-to-package input-output interconnect count increases by 10-20X. The profound and pervasive nature of the interconnect problem demands commensurate response. The central thesis of this response is that early XXI century opportunities for GSI will be governed by an interconnect dominated hierarchy of theoretical and practical limits whose five levels are codified as fundamental, material, device, circuit and system. Systematic exploration of this hierarchy of limits reveals salient opportunities for addressing the interconnect problem.

Could you please replace this abstract with page 4 (P2) in the EXTENDED ABSTRACTS.  
The publisher would like to apologize with sincerity for the mistake.  
Thank you for your consideration.

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$$\omega T = 1.38 \times 10^{-23}$$

300

$$\frac{e \times 10^{-21}}{1}$$

AT

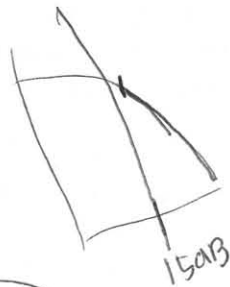
$$1.602 \times 10^{-19}$$

$$3 \times 10^{-21}$$

$$E_b = \frac{e^2}{144 C_0}$$

$$\frac{1000 \times 10^{-10}}{10^{-1}}$$

$$\omega T$$



$$\frac{1}{2} C_0 v_0^2$$

$$\frac{2 \times 10^{-16}}{2 \times 10^{-16}}$$

$$\frac{e^2 C_0}{144 C_0}$$

$$\frac{e}{c}$$

$$\frac{1.6 \times 10^{-19}}{144} \times 10^{-19} = \frac{1.6 \times 10^{-38}}{144}$$

$$10^{-22} (T)$$

