

Practical Supply and Threshold Voltage Scaling for Energy Efficient Operation of Microprocessors

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 Highest energy efficiency can be obtained at Near-Threshold Voltage (NTV)



Discuss how we can enjoy NTV computing

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Dynamic V_{DD} and V_{TH} Scaling

- DVFS (Dynamic Voltage and Frequency Scaling) —Large impact on dynamic energy
- ABB (Adaptive Body Biasing)
 - -Large impact on static energy

-Process/Activity/Temperature variation compensation

N. Mehta, B. Amrutur, "Dynamic Supply and Threshold Voltage Scaling for CMOS Digital Circuits Using In-Situ Power Monitor," IEEE Trans. VLSI Systems, vol.20, issue 4, pp.892-901, May 2012.

L. Yan, J. Luo, and N. K. Jha, "Joint Dynamic Voltage Scaling and Adaptive Body Biasing for Heterogeneous Distributed Real-time Embedded Systems," IEEE Trans. on Computer-Aided Design, vol. 24, July 2005.

S. M. Martin, K. Flautner, T. Mudge, D. Blaauw, "Combined Dynamic Voltage Scaling and Adaptive Body Biasing for Lower Power Microprocessors Under Dynamic Workloads," in Proc. of ICCAD, pp.721-725, November, 2002.

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Minimum Energy Point





Properties for E_{min} Curve





Implications for Practical DVS



京都大学 Voltage Scaling for Super-Threshold

• Strong inversion operation $(V_{DD} >> V_{TH})$











E_{loss} Introduced by Fixed Voltages

Temperature and activity may change independently

 E_{loss} introduced by using a single fixed voltage setting

- for different activity factors: STV ~ 8%, NTV ~12%
- for different temperature conditions: STV ~ 7%, NTV ~7%





Summary

- Guidelines proposed for practical voltage scaling
 - Divide the voltage region into two regions
 - Super-threshold (STV): High-end severs in data center
 - Near-threshold (NTV): Wireless sensor network, IoT
 - Use DVFS for STV operation: fixed V_{TH} is sufficient
 - 3 to 4 different V_{DD} s is preferable
 - Use ABB for NTV operation: fixed V_{DD} is sufficient
 - Small number of different V_{TH} s is sufficient
 - Fixed V_{DD} is still effective for NTV even if PAT vary
 - Process/Activity/Temperature variation compensation