Body Bias Optimization for Variable Pipelined CGRA
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Introduction
VPCMA [1] is a CGRA (Coarse Grained Reconfigurable Architecture) providing a variable pipeline structure in its PE array. Also, it is implemented with the SOTB technology. The pipeline structure and body bias voltage can be changed in order to balance its performance and power consumption. In this work, we propose an optimization method for pipelined CGRA including VPCMA.

VPCMA (Variable Pipelined Cool Mega Array)
- PE (Processing Element)
- Power reduction
- No register file
- No clock tree
- No dynamic reconfiguration
- Pipeline Register
- Selection upon use
- Variable pipeline structure
- PE Array
- 12 cols × 8 rows of PEs
- 7 pipeline registers

Architecture
- Row level body bias control
  - Each PE row is supplied independent body bias voltage.
  - Balance of the delay time of each pipeline stage
  - Decreasing the delay time of the critical path
  - Increasing the delay time of the other paths
  - More power reduction

Optimization Method
- Dependencies of each criteria
  - Static power
  - Depends on body bias voltage
  - Linear function
- Delay time (Performance)
  - Depends on body bias voltage, mapping & pipeline structure
- Dynamic power
  - Depends on delay time & pipeline structure

Optimization Flow with ILP (Integer Linear Program)
- Dynamic power is constant
- Static power optimization can be formulated as an ILP
- Delay time can be considered to be constraints of the ILP

Results of Simulation
- Simulations
  - 4 image process application programs
  - SOTB – 2016, pp. 231-238.
- Comparison with other body bias control methods
  - Using body bias control
  - Extends performance limitation
- Comparison with VDD control
  - Suitable control for high performance
  - Uniform
  - Using VDD control is better
  - Proposed method
  - Using Body bias control is better

Complex Trade-off
- Body bias voltage
  - Low Performance, Small Leak Power
  - High Performance, Large Leak Power
- Pipeline structure
  - Large: Dynamic power of registers and clock
  - Small: Dynamic power of glitches

Combination of pipeline structure and body bias control
- Body bias voltage: 13 values (-2.0, -1.8, -1.6, ..., 0.4 V)
- Pipeline structure: 128 patterns (2^7)
- 13^8 × 128 possible solutions