On High-Performance Parallel Decimal Fixed-point Multiplier Designs

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Introduction

Decimal computations are required in finance, and etc.

- Precise representation for decimals (E.g. 0.2, 0.7...)
- Performance Requirements (Software simulations are very slow)

Traditional Approach (8421 BCD)

$$\begin{aligned} P_{2n} &= A_n \times B_n \\ &= A_n \left(\sum_{i=0}^{n-1} b_i (10)^i \right) \\ &= \sum_{i=0}^{n-1} A_n b_i (10)^i \\ &= \sum_{i=0}^{n-1} PP_{i_{n+1}} (10)^i \end{aligned}$$

$$\begin{array}{r} \times \quad \begin{array}{cccc} a_3 & a_2 & a_1 & a_0 \\ & & & b \end{array} \\ \hline \begin{array}{cccc} pt_3 & pt_2 & pt_1 & pt_0 \\ + & c_3 & c_2 & c_1 & c_0 \\ \hline pp_4 & pp_3 & pp_2 & pp_1 & pp_0 \end{array} \end{array}$$

A	0010	0101	0111	0101
B	+ 0011	0100	0010	1000
Sum 1	0101	1001	1001	1101
Correction 1	+ 0000	0000	0000	0110
Sum 2	0101	1001	1010	0011
Correction 2	+ 0000	0000	0110	0000
Sum 3	0101	1010	0000	0011
Correction 3	+ 0000	0110	0000	0000
Result	0110	0000	0000	0011

My Architecture (8421-5421 BCD)

$$\begin{aligned} P_{2n} &= A_n \times B_n = \sum_{i=0}^{n-1} A_n b_i (10)^i \\ &= \sum_{i=0}^{n-1} A_n (b_{0i} + b_{1i}) (10)^i \\ &= \sum_{i=0}^{n-1} (A_n (b_{0i}) + A_n (b_{1i})) (10)^i \\ &= \sum_{i=0}^{n-1} (PP0_{i_{n+1}} + PP1_{i_{n+1}}) (10)^i \end{aligned}$$

$$b_i = 5 \times b_{iH} + (-1)^{OP} b_{iL}$$

$b_{iH}, b_{iL} \in \{0, 1, 2\}, OP \in \{0, 1\}$

Conclusion:

- Best designs in terms of delay and delay-area product.
 - Simplified logic of PPG with 8421-5421 recoding.
 - 8421 CLAs organized as tree structure for PPA
- Could be pipelined for higher data throughput and hardware utilization

Evaluation Results