Survey Report on Carry Save Adder

Anubhav Dinesh Patel (218)
anubhavp28@gmail.com
IIIT Kalyani, West Bengal, India

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1. Introduction

A carry-save adder is a type of digital adder, used in computer microarchitecture to compute the sum of three or more n-bit numbers in binary. It differs from other digital adders in that it outputs two numbers of the same dimensions as the inputs, one which is a sequence of partial sum bits and another which is a sequence of carry bits.

There are many cases where it is desired to add more than two numbers together. The straightforward way of adding together m numbers (all n bits wide) is to add the first two, then add that sum to the next, and so on. This requires a total of $m - 1$ additions, for a total gate delay of $O(m * lg(n))$ (assuming lookahead carry adders). Using carry-save adder, a gate delay of $O(m + lg(n + m))$ can be achieved.

Carry save adder is consists of three or more n-bit binary numbers. Carry save adder is similar as full adder. Here we are computing sum of 3-bit binary numbers, so we take 3 full adders at first stage. Carry save unit consists of 6 full adders, each of which computes single sum and carry bit based only on the corresponding bits of the two input numbers [1].

Let X and Y are two 3-bit numbers and produces partial sum and carry as S and C as shown in the Table 1.

$$Si = Xi \oplus Yi$$

$$Ci = Xi + Yi$$

Table 1. Carry save Adder Computation.

	X:		1	0	0	1	1
	Y:		1	1	0	0	1
+	Z:		0	1	0	1	1
	S:		0	0	0	0	1
+	C:		1	1	0	1	1
	Sum:	1	1	0	1	1	1

2. **Past Development**
While carry-save adders are rarely used for addition on modern general-purpose CPUs, they are used to construct Wallace Trees. Wallace Trees are combinatorial logic circuits used to multiply binary integers. They are a fast, efficient method to implement multiplication . Since these adders do not propagate carry values between bits, they can produce multiplication products faster than other multiplication hardware[2].

Carry-save adders are also used to construct circuits for modular multiplication. Most number-theoretic cryptosystems, such as RSA cryptosystems, are constructed based on modular multiplications. The design and VLSI implementation of fast algorithms for modular multiplication is a key to high-speed encryption/decryption cryptosystems [3].

3. **Current Status**
Several faster combinatorial circuits for binary addition has been proposed, such as carry look-ahead adder (CLA) and carry skip adder (CSKA), which makes carry-save adders obsolete for binary additions. Carry-save adders have found use within circuitory for other types of computation (such as multipliation). Research effort going forward will be about using carry-save adders to implement combinatorial circuits for more complex computation than binary addition.

4. **Conclusion**
Though carry-save adders were developed for binary additon of more than 2 numbers, it is now mainly used as a building block of implementations of complex algorithms.

References

[1] Jayasimha, Lakshmi, Kannan, and Daka, "Implementation of high performance carry save adder using domino logic," Mar 2017.

[2] M. Dokachev and J. Carpinelli, "The wallace tree simulator," Mar 2015.

[3] "Fast modular multiplication with carry save adder - ieee conference publication."