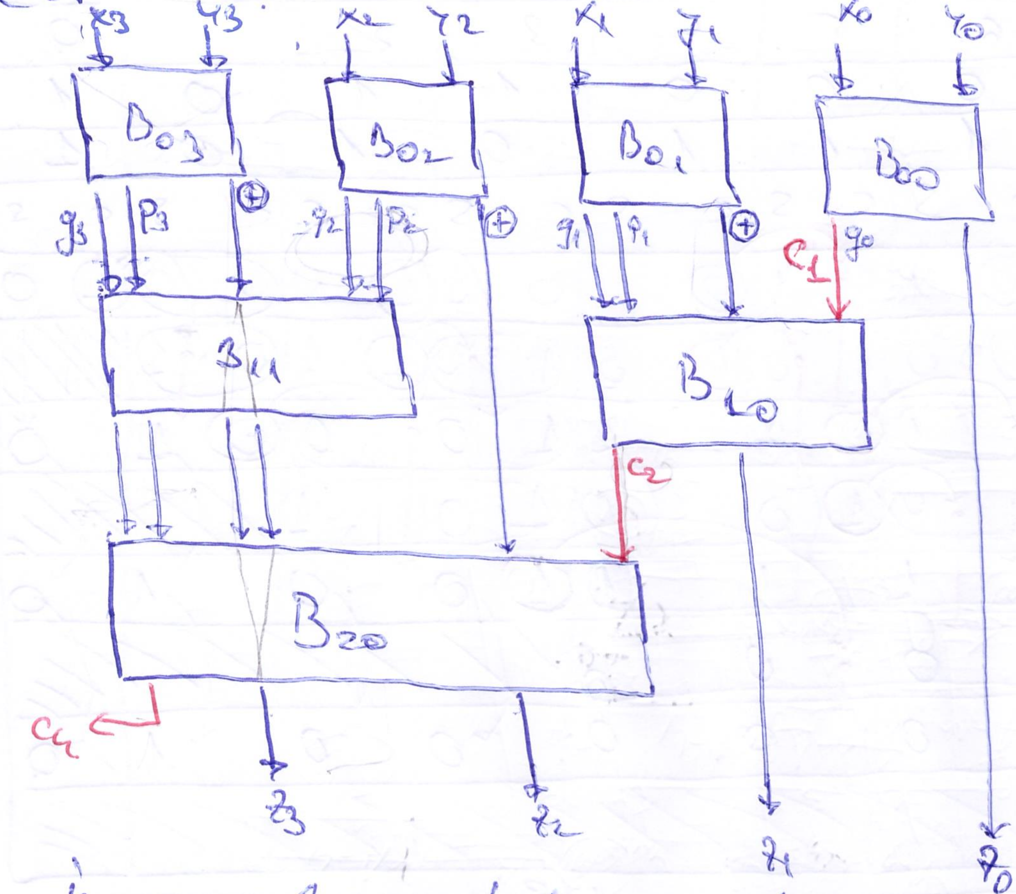
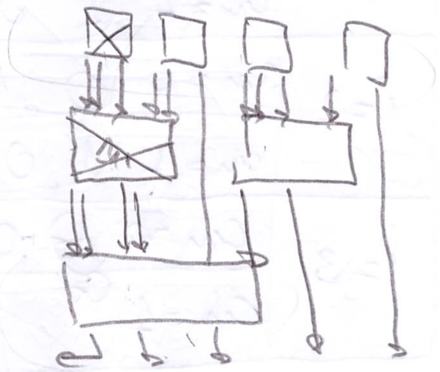
ACA : 4-bit CSuA



! block diagram of a 8-bit CSuA.



in general: n-bit operands

$$\Delta^{z}_{CSuA-n} = \underbrace{2d}_{exor} + 2\lceil \log_2 n \rceil d = 2(\lceil \log_2 n \rceil + 1)d.$$

4 bit → 2 nivel.
n bit → $\lceil \log_2 n \rceil$

$$\Delta^{cout}_{CSuA-n} = 1d + 2\lceil \log_2 n \rceil d = (2\lceil \log_2 n \rceil + 1)d.$$

Comparison: n = 64 bits

CSuA:	CSeA: $(n+2)d$	ML-CLA:	RCA
$\Delta^{z} = 14d$	$\Delta^{z} = 66d$	$(4\lceil \log_2 n \rceil + 1)d$: $\Delta^{z} = 25d$.	$\Delta^{z} = 128d$.
$\Delta^{cout} = 13d$.	$\Delta^{cout} = 66d$	$(2\lceil \log_2 n \rceil + 3)d$: $\Delta^{cout} = 15d$.	$\Delta^{cout} = 128d$

Example:

$X = 1000\,1101 = 128 + 13 = 141$

$Y = 0111\,0101 = 112 + 5 = 117$

$c_0 = 0$!!!

i=1 i=2 i=1 | i=1 i=2 i=1

Operands \ Rank		7		6		5		4		3		2		1		0	
X		1		0		0		0		1		1		0		1	
Y		0		1		1		1		0		1		0		1	
Block level	Carry in	C	S	c	S	c	S	c	S	c	S	c	S	c	S	c	s
i=0	cin=0	0	1	0	1	0	1	0	1	0	1	1	0	0	0	1	0
	cin=1	1	0	1	0	1	0	1	0	1	0	1	1	0	1		
i=1	cin=0	0	1		1	0	1		1	1	0		0	0	1		0
	cin=1	1	0		0	1	0		0	1	0		1				
i=2	cin=0	0	1		1		1		1	1	0		0		1		0
	cin=1	1	0		0		0		0								
i=3	cin=0	1	0		0		0		0		0		0		1		0
	cin=1	8															

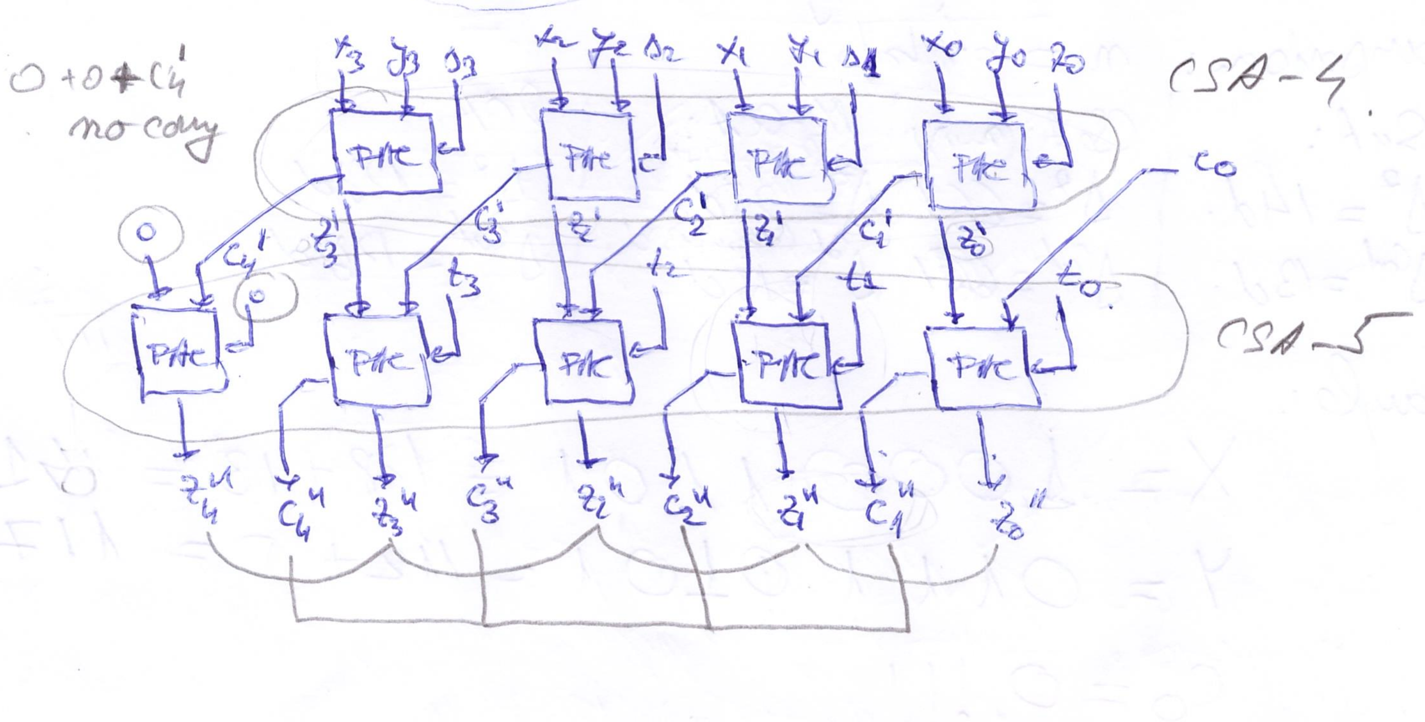
i=3

1.4.5. Carry Save Adder (CSA)

- result in redundant form: 2 vectors → sum, carry
  - carry vector is 1 bit more significant.
- multi-operand addition:

Let X, Y, S, T – 4-bit operands

$$Z = X + Y + S + T$$

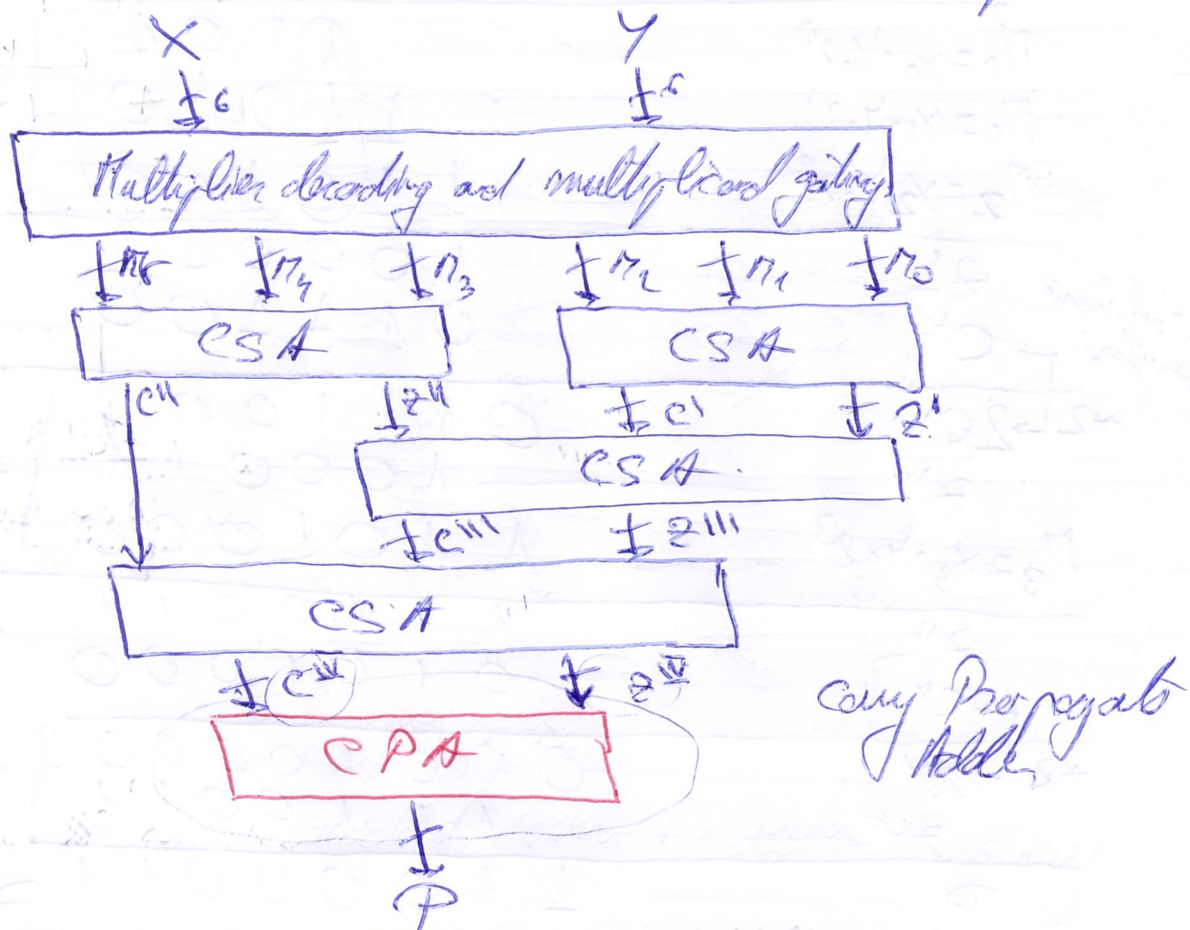


- facilitates multiplication (combinational)

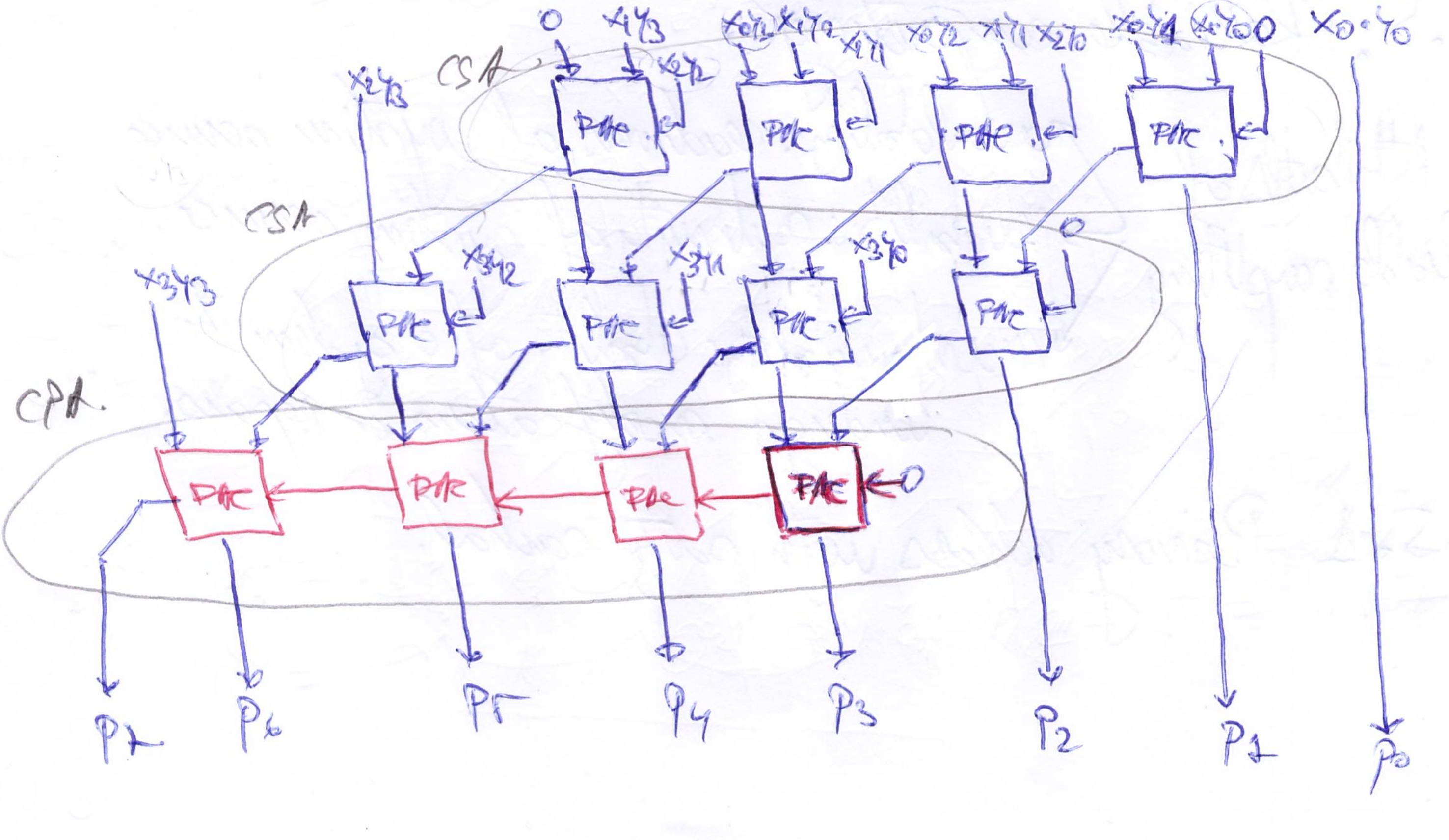
Let X, Y - unsigned, 6-bits

$P = X * Y \rightarrow$ 1-bit product $M_i = x_i * Y \cdot 2^i$

$\rightarrow$ add the 6 1-bit products.



Example: X, Y - unsigned, 4-bits.



Z. $X = 15 \quad Y = 13$

					x_3	x_2	x_1	x_0	
$X = 15$					1	1	1	1	
$Y = 13$					1	1	0	1	
$M_0 = x_0 \cdot Y \cdot 2^0$					1	1	0	1	$+t_{CSA}$
$M_1 = x_1 \cdot Y \cdot 2^1$				1	1	0	1	0	
$M_2 = x_2 \cdot Y \cdot 2^2$			1	1	0	1	0	0	
Z'			1	0	0	0	1	1	
C'			0	1	1	1	0	0	
$\times 2$: $2C'$		0	1	1	1	0	0	0	$+t_{CSA}$
Z'			1	0	0	0	1	1	
$M_3 = x_3 \cdot Y \cdot 2^3$		1	1	0	1	0	0	0	
Z''		1	1	1	0	0	1	1	
C''		0	1	0	1	0	0	0	
$\times 2$: $2C''$	0	1	0	1	0	0	0	0	$+t_{CPA}$
Z''		1	1	1	0	0	1	1	
P	1	1	0	0	0	0	1	1	$= 195$

1-bit more significant

$3 \cdot 2^6 + 3 = 3(64+1) = 65 \cdot 3 = 195$

1.5. Reliable computing.

Attributes of reliable computing:
- availability: readiness of system service.
- reliability: continuity of system service.
- maintainability: ability of a system to undergo modifications & repairs.

1.5.1 Binary adders with parity control.