CS2318
01/23/18

Encode Decode

BCD Binary Coded Decimals

DIS - Decimal Instruction Set

BCD [0 - 9] → 4 bits

1100 (Hex C) is not a legal BCD

$$\begin{array}{r} d_a \\ + \quad d_b \\ \hline T_c \end{array}$$ if $d_c < 10$ it is fine

$$\begin{array}{rr} 33 & 0011\ 0011 \\ 44 & 0100\ 0100 \\ \hline & 0111\ 0111 \end{array}$$

$$\begin{array}{rr} '7' & 0111 \\ '5' & 0101 \\ \hline & 1100 \end{array}$$ 1100 → 9

0001 0010 IL 18

2

		0001	
35	+	0011	0101
37		0011	0111
		0111	0010

Intel provision to check that the result of $(a+b) > 9$

Finite Length Representation (Registers)

Fixed

Assume a finite length Reg

Unsigned INTS $0, 1, 2, \ldots$

Assume n bits Registers (e.g., 32)

2^{32} symbols $\Rightarrow [0, 2^{32}-1]$

n bits 2^n symbols $[0 .. 2^n - 1]$

3

0 - 000...0

$2^n - 1$ 11111...

Unsigned $\Rightarrow \sum_{i=0}^{n-1} b_i 2^i$

$b_{n-1}, b_{n-2}, \ldots, b_1, b_0$ ⟶ Decimal Equivalent

$(X)_{10}$ consecutive division

$\Rightarrow (X')_2$ $\quad 0 \leq X \leq 2^n - 1$

Fixed point Representation

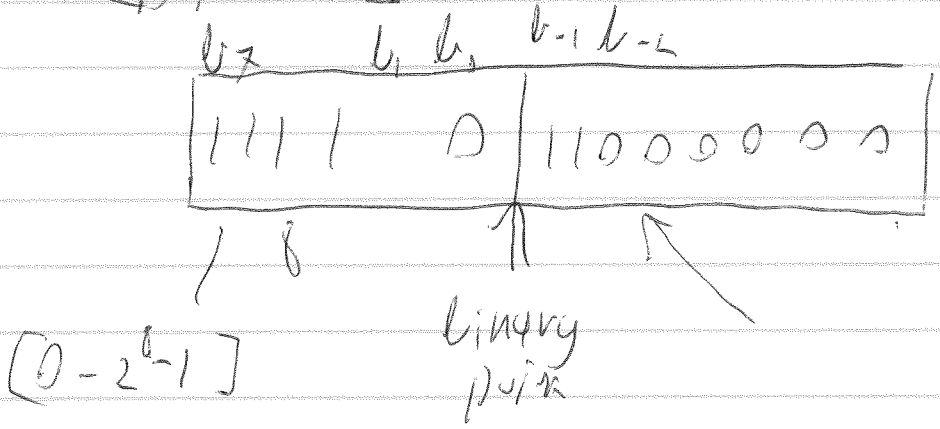
We Fix an imaginary radix point (binary)

inside the register on to the left of the register

MIPS Division Hi & Lo

4 16 bits No fixed point

$[0, 2^{16}-]$

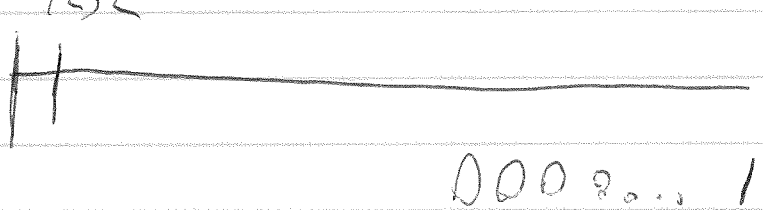


$$\sum_{i=-8}^{7} b_i 2^i$$

$254 + \frac{1}{2} + \frac{1}{4}$ $254\frac{3}{4}$

$255 \frac{255}{256}$ (11111, 11111)

follows from equation



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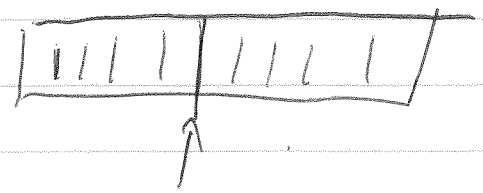
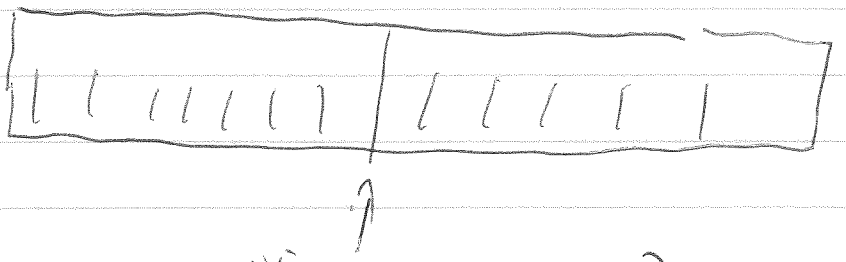


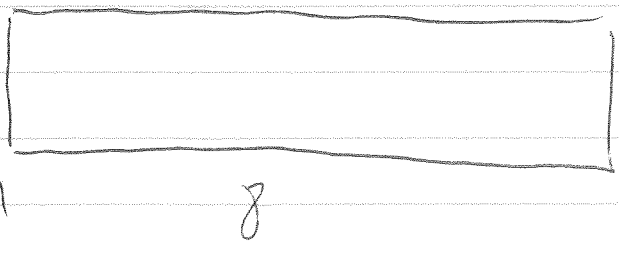
15 $\frac{15}{16}$

15 $\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16}$ $\frac{8+4+2+1}{16}$



255 $\frac{255}{256}$ 256)

[0 .. 256)



Binary [0, 1) $\frac{255}{256}$

Next to 0 $\frac{1}{256}$

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Sign number Representation

Sign + Magnitude

1's complement ((R-1)'s)

2's " (R's)

Addition in Unsigned #

```
  1 1 1 1 1
a 0 1 0 1 0 1
b 0 1 1 0 1 1
-------------
1 1 0 0 0 0
```

```
  1 0 1 0
  1 1 0 0
-----------
1 0 1 1 0
```

Cin	a	b	R	Cout
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

over flow

if C == 1

carry from MSD

=> OVF

7a G_i - Generated in unit if $a = b = 1$

	1	1	
a	0	1	$P_i = (a_i \oplus b_i) = 1$
b	1	0	

1
0
0

steps

subtraction might lead to negative numbers $a - b$ $b < a$

$$\begin{array}{r} {}^{1}{}^{2} \\ 0\ 1\ 0\ 0\ 1 \\ 0\ 0\ 1\ 1\ 1 \\ \hline 0\ 0\ 1\ 1\ 0 \end{array}$$

borrow

$$\begin{array}{r} {}^{8}{}^{10} \\ 8\ 9\ 0\ 0\ 1 \\ 0\ 0\ 1\ 1\ 1 \end{array}$$

Find th

7 Agreement MSB is sign

b

0 is positive 1 is negative

↓

$$\begin{array}{r} 0\,1\,1\,0 \\ +\ 0\,0\,0\,1 \\ \hline 0\,1\,1\,1 \end{array}$$

4 bit reg

$a > 0$, $b > 0$ $a + b$

$S + M$ carry from MSB of M

$$\begin{array}{r} 0\,1\,1\,1 \\ 0\,0\,0\,1 \\ \hline (1)\,0\,0\,0 \end{array}$$

overflow

/

Most Significant Bit

LSB

$S + M$ $S_A\ M_A$

$S_B\ M_B$

$S_R = S_A \oplus S_B$

$S_R\ M_R$

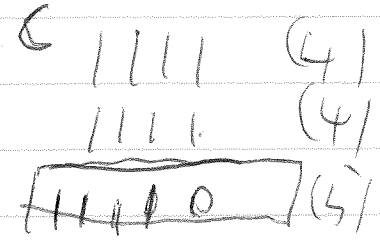
$M_R = M_A \times M_B$

8 A |A| size of A is n bit

B |B| " " B is N

|C| is upto n+(1) bit

C



$|A| = n$

$|B| = n$

$|A \times B| = 2n$

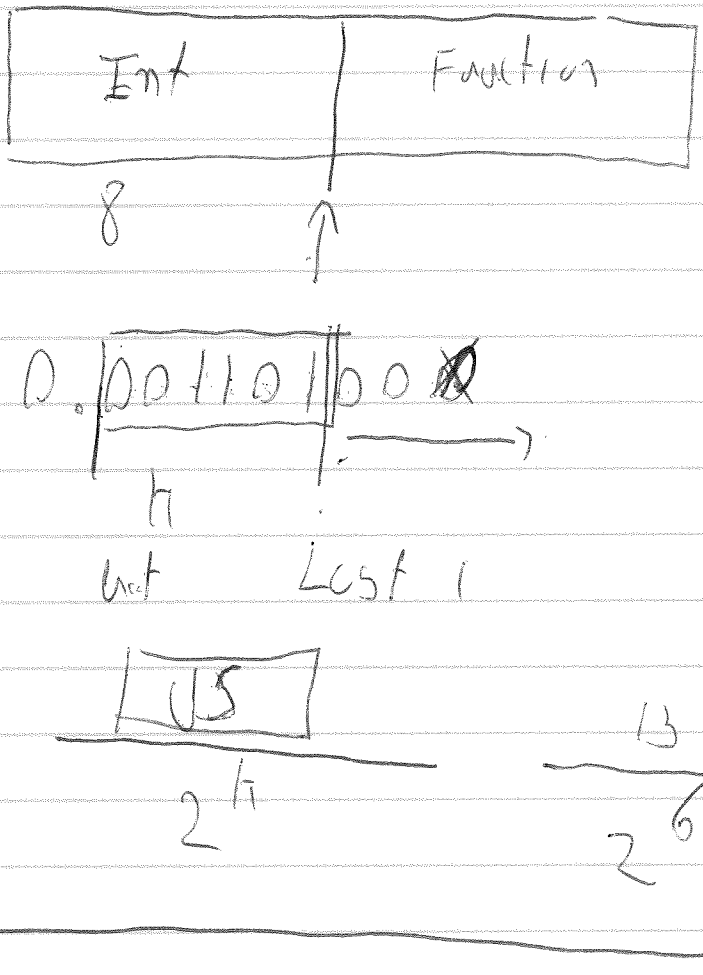
$|A / B|$ $2n$ $n \cdot n$

↑ ↑

inf Mod

9

short cut for fractions



10

0000 +0 S+M 4bit

1000 -0 S+M

2 Representations for 0

n bits S+M

$[-2^{n-1}-1 , +2^{n-1}-1]$

0011
0111

=> Find the smaller

subtract

Adjust sign

Make decison:

Adder subtruder

want to do A-B as

A + (-B) X in S-M

11 $a + (-a) \stackrel{?}{=} 0$

$$\begin{array}{r} 0011 \\ 1011 \\ \hline 1110 \end{array}$$

$(a)_{sm} + (b)_{sm} \neq (a)_{sm} + (-b)_{sm}$