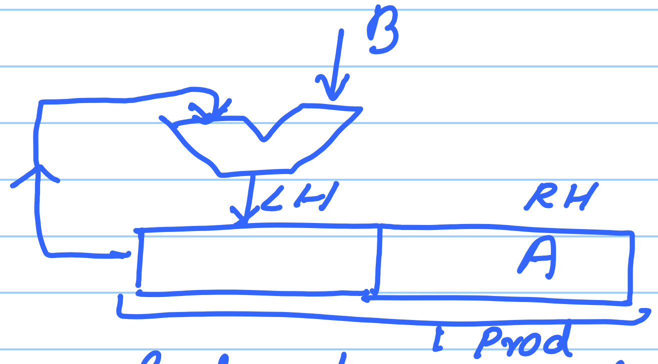
Sept 14

Note Title 14-09-2011

Multiplication (Bit by Bit)



(32) (32) (64)
A × B = P

```
        4
   ×  1 1 0 0    (B)
      1 0 1 1  4 (A)
   ------------
      1 1 0 0
    1 1 0 0
  0 0 0 0
1 1 0 0
------------------
1 0 0 0 0 1 0 0
        8 bits
```

1) Take a look at LSB of A

2) If (LSB == 1)
   LH += B
   If (LSB == 0)
   Nothing

3) Right shift Prod.

4) Go back to step 1

Repeat this loop 32 times

Example: 1100 {Unsigned Multiplication)
×1011

1) | 0000 | 1011 |

LSB

| 1100 | 1011 |

| 01100 | 101 |

LSB

2) | 01100 | 101 |

+1100

LSB

| 1 | | 00100 | 101 |

| 100100 | 10 |

3) 100100 | 10
LSB

0100100 | 1

4) 01001100 | 1
+ 1100

1 | 00001001 | 1

RS:

10000100

Differences from Division

Multiplication	Division
1) Right Shift	1) Left Shift.
2) Check LSB of A	2) Compare with LH
3) You save the carry. It is required while Right shifting	3) Not Required.
4) Complexity ($O(n \log(n))$)	$O(n \log(n))$

Class on Friday: 11 to 12:30.

Tutorial sheet Posted on the website : Sep 12th Week
Try to Solve
Discuss with TA

Floating Point Numbers

$\underbrace{1.3578}_{\text{Real or FP Number}}$

How to represent FP numbers in binary?

$\underset{x_4}{1}\ \underset{x_3}{0}\ \underset{x_2}{1}\ \underset{x_1}{1}\ \underset{x_0}{1}$: $\underbrace{\sum x_i 2^i}$ —

$$\underbrace{10111}_{x_4\, x_3\, x_2\, x_1\, x_0}.\underbrace{110}$$

$$\underbrace{\cdot\ \overset{1}{x_{-1}}\quad \overset{1}{x_{-2}}\quad \overset{0}{x_{-3}}}_{\sum_{i=-1}^{-3} x_i \times 2^{-i}}$$

Example: $(1.5)_d = (1.1)_b$

$(4.375)_d = (100.011)_b$

0.5 0.25 0.125 0.0625

IEEE 754 Format

1	8	23
Sign Bit	Exponent (E)	Mantissa (m) (Significand)

$1 + 8 + 23 = 32$

Number : $\left[1.(m) \times 2^{E-127}\right]$ {Normalized Form}

Exponent : Biased / Offset Notation

E: 255, 254, ..., 1, 0

254 to 1: $(E-127)$ {+127 to −126}

S	E	m	Value
NA	0	0	0
+/-	0	≠0	Denormal numbers
+/-	255	0	+/- ∞
NA	255	≠0	NAN (Not a number)

NAN : $0/0$ NAN | ∞/∞ NAN

NAN + 1 = NAN

NAN × 23.2 = NAN

Denormal Numbers:

What is the smallest positive normal number?

$1.000\text{---} \times 2^{-126} = 1 \times 2^{-126}$

Denormal Number:

$(+/-)\ 0.m \times 2^{-126}$

What is the largest (+)ve denormal Number?

$(+)\ 0.\underbrace{11\ \cdots\ 1}_{23} \times 2^{-126}$

$= 1 \times 2^{-126} - \epsilon$

$2^{-1} + \cdots 2^{-23}$

$= 1 \times 2^{-126} - 2^{-149}$

$= 2^{-1}(1 + \cdots 2^{-22})$

$= \cancel{2^{-1}} \dfrac{(1-2^{-23})}{\cancel{2^{-1}}} = (1-2^{-23})$

Because of precision: FP calculations are not exact:

Is: $(x+y > x)$? $\left(\begin{matrix} x>0 \\ y>0 \end{matrix}\right)$

maybe???

$x = 1$

$y = 2^{-50}$

How would you represent $x+y$?

HW will round $(1+2^{-50})$ to 1

$$(x+y) == (x) \quad \{!!!\}$$

Friday

more of this, Double Precision

'Add / Sub / Mult / Divide