28 Sep

Admin

Exam 1
↳ Wed, Sep 30
in-class, 90min

- practice out
up to last week
Sep 23/24/25

Agenda

- Binary addition
- Two's complement

- Practice Exam Review

Binary Addition

$3_{10} \longrightarrow$
$+\ 5_{10} \longrightarrow$
8_{10}

carry: 1 1
$\quad 1\ 1_2$
$+\ 1\ 0\ 1_2$
$1\ 0\ 0\ 0_2$

$0+0 \to 0$
$0+1 \to 1$
$1+0 \to 1$

$1+1 \to 10$

$4+9 \to 18$ (carry)

$1+1+1 \to 11$

carry: 1 1
$\quad 3$
$+\ 7$
10

carry: 1 1
$\quad 1\ 1$
$+\ 1\ 1\ 1$
$1\ 0\ 1\ 0$

Subtraction (via addition): $4 - 3 = +4 + (-3)$

1st idea: use a "sign bit" : $-3_{10} \to -11_2 \to$ signed binary $1\ 11$ (1 = "-" signbit, 11 = unsigned binary $\to 3$)

4-bit signed binary / 8-bit

-3: 1 0 1 1
↑ sign bit

-3: 1 0000011
↓ sign bit ↳ "3"

4-bit signed

(-1) + (-1) →
  1001
  1001
 10010 → $0010_2 = 2_{10} \neq -2$

Incorrect

Two's Complement

0. Decide # of bits to use

→ Positive #s are 0 ⟶ std. bin. repr.

eg. 8-bit

4_{10}: 00000100
↓ sign ↓ 4

→ Negative #s are more complicated

$-n < 0 \Rightarrow n \geq 0$

i) n in binary
ii) flip all bits
iii) add 1
↳ 2's complement repr of "-n"

$-n \rightarrow ① \rightarrow ② \rightarrow ③$
$① \leftarrow ② \leftarrow ③$

eg. 8-bit

-9 → i) 00001001
ii) 11110110
iii) 11110111
↳ -9 in 8-bit 2's compl.

From 2's compl ⟶ Decimal

i) subtract 1
ii) flip all bits
(Original #)

iii) bin → dec. (add = 8

8-bit

4 + (-9) —2's compl→ 0000 0100 + 1111 0111 = 1111 1011 —-1→ 1111 1010

1111 1011 → -ve #

1111 1010 → flip bits → 0000 0101 → -5_{10}

$100_2 - 1_2 = 11_2$

4-bit 2's compl

-2^3-1 X | $-2^3, \ldots, -1, 0, 1, \ldots, 2^3-1$ | 2^3 X

largest

7 → 0111

6 → 0110

5 → 0101

⋮

1 → 0001

0 → 0000

-1 → 1111

-2 → 1110

0111 → 7

0001 → 1

1000 → 8?

↳ -8

if +ve + +ve → -ve

or -ve + -ve → +ve

-8 → 1000

that's overflow!

you don't have enough bits.