CS1800
9/29-Tues.

Admin

- exam Fri (10/2)
- PS3 at sat (10/3)

Agenda

0. Review - number conversions
1. Two's complement
2. Exam review

0. Review - number conversions

$____2 = ____{10}$?

base 2 → base 10

- multiply value by power of 2

$____{10} = ____2$?

- repeated by divide by 2
- track remainders

(ex) $1010_2 = ____{10}$?

8 4 2 1

$= 0 \cdot 1 + 1 \cdot 2 + 0 \cdot 4 + 1 \cdot 8$

$= 2 + 8$

$= 10_{10}$

(ex) $13_{10} = ____2$?

13 / 2 = 6 R 1

6 / 2 = 3 R 0

3 / 2 = 1 R 1

1 / 2 = 0 R 1

↳ 1101_2

in general... same steps

base b → base 10

base 10 → base b

b → 10

$\frac{_}{b^3} \quad \frac{_}{b^2} \quad \frac{_}{b^1} \quad \frac{_}{b^0}$

10 → b

10 / b, keep remainder

base 7 → base 10

$432_7 = ____{10}$?

$\underset{7^2}{4} \quad \underset{7^1}{3} \quad \underset{7^0}{2} = 4 \cdot 7^2 + 3 \cdot 7^1 + 2 \cdot 7^0$

$= \boxed{219_{10}}$

$397_{10} = ____5$?

397 / 5 = 79 R 2

79 / 5 = 15 R 4

15 / 5 = 3 R 0

base 5 → base 10

$3042_5 = ____{10}$?

$\underset{5^3}{3} \quad \underset{5^2}{0} \quad \underset{5^1}{4} \quad \underset{5^0}{2} = 3 \cdot 5^3 + 0 \cdot 5^2 + 4 \cdot 5^1 + 2 \cdot 5^0$

$= \boxed{397_{10}}$

$219_{10} = ____7$?

219 / 7 = 31 R 2

31 / 7 = 4 R 3

4 / 7 = 0 R 4

↳ $\boxed{432_7}$ ☺

$315 = 0R3$ → 3042_5 :)

1. Two's Complement

↳ system for pos, neg, 0

So far... number conversions unsigned!

subtraction = adding negative number

adding binary numbers

$0 + 1 = 1$

$1 + 1 = 10$

$1 + 1 + 1 = 11$

$10 + 11 = 101$

$101 + 100 = 1001$

$111 + 111 = 1110$

$101 + 101 = 1010$

only has 0/1, no separators

uses same # bits for every number

1010? 10 10 ?

101 0?

Two's complement:

- can't add extra column
- every number same # bits
- usually 32, 64 bits (& smaller)
- always numbers to be signed
- leftmost bit: sign bit

0 pos, 1 neg

Always specify # of bits! → 3 bit two's complement

convert from decimal to 2's comp

1. If positive, just convert!

   If necessary, pad at bits

ex) 3_{10} to 4 bit 2's complement

0 0 1 1

2. If negative, pretend it's positive + convert.

   Flip bits.

   Add one.

011	3
010	2
001	1
000	0
111	-1
110	-2
101	-3
100	-4

ex) -3_{10} to 4 bit two's comp

0 0 11

Flip 1 1 00

Add one: $1100 + 1 = 1101$

- 5_{10} to 4-bit 2's comp 0101
- -5_{10} to 4-bit 2's comp 1011

↳ pos 5 0101

Flip 1010

Add $1010 + 1 = 1011$

ex 6_{10} to 4-bit 2's comp

0110

-6_{10} to 4 bit 2's comp

pos 6 0110

Flip 1001

Add $1001 + 1 = 1010$

overflow: value doesn't fit in # bits → what it is

do the computation

use the given # bits

neg + neg = pos? overflow. → how we know

pos + pos = neg?

ex 4 bit 2's comp

overflow!

$$\begin{array}{r} 0101 \\ +\ 0101 \\ \hline 1010 \end{array}$$

pos!

↳ neg!

ex $-3 + -6$

$$\begin{array}{r} 1101 \\ +\ 1010 \\ \hline 0111 \end{array}$$

neg!

overflow!

↳ pos!

2:57

- add neg+neg=pos
- add pos+pos=neg

exam fri :)

¬ not

circuits/TT logical equiv. implication

preds + quant number conversions