CS 225: Switching Theory

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Previous Class

- Number Systems and Codes
  - Different Number systems (positional)
  - Conversion
  - Representation (complement)
  - Binary Arithmetic

This Class

- Number Systems and Codes
  - Codes
    - BCD, cyclic code etc.
    - Gray code
    - Parity and Error correcting code

Signed binary number

Positive numbers can be defined with Sign bit 0

- Ex. In 8-bit representation of +9 = 00001001

- Negative numbers can be represented in three different ways:
  - Signed magnitude: -9 = 10001001
  - Signed 1's complement: -9 = 11110110
  - Signed 2's complement: -9 = 11110111

- Undesired aspect in signed binary and 1 s complement method:

- representation of 0s:

  +0 has different code from -0

Radix Complements (r-1's complement)

- r-1's Complements:
  - Diminished Radix (r-1)'s Complement
    - (r-1)'s complement of a number N with n digits is $(r^n - 1) - N$.

Ex.:9's complement of 346 is 999-346=653 (10^3 -1= 999)

  - 1's complement of a binary number can be determined as just replacing 1's with 0's and vice- versa..

Radix Complements (r's complement)

- Radix complement:
  - r's complement of a number N with n digits is $r^n - N = (r^n - 1) - N + 1$.

Ex. 10's complement of 346 is = 654 (653+1)

2's complement of 1011= 0101

NB: complement of complement of N is N $r^n - (r^n - N) = N$

Subtraction using r's complement

- Addition
  - Care for overflow
- Subtraction:
  - Complements:
- M and N are two n digit numbers with radix r
- To subtract N from M
  - Compute the r's complement of N (= r^n – N)
  - Add M with r's complement of N i.e. M - N + r^n

If M >= N result produce the carry r^n which may be discarded so resulting M –N

If M<N result does not produce carry that may be treated as . M- N + r^n = r^n – (N – M) so the answer is r's complement of the result.

Overflow

- Overflow is said to occur if the result needs more than n-bits.
- If c is a carry into the sign-bit position and o is the carry from sign-bit position; then overflow is said to occur if and only if c XOR o = 1

Ex.:

Answer the following

Q1. $(1010100)_2$ - $(1000011)_2$ =? Use 2'complement method

Ans.: 10010001 =0010001 (17=84-67)

Q2. $(1000011)_2$ - $(1010100)_2$ =? Use 2'complement method

Ans.: _1101111 = -0010001 (-17=67-84)

Q3. $1100101_2 \times 111101_2 = ?$

Ans.: 1100000010001 (101 x61 =6161)

Q4. $100101_2 \div 101_2 = ?$

Ans.: Q= 111, rem= 10 ($37_{10} \div 5_{10}$ = Q(7), rem(2))

Binary Coded Decimal (BCD)

To code a number with *n* decimal digits, we need *4n* bits in BCD

e.g. $(365)_{10} = (0011\ 0110\ 0101)_{BCD}$

This is different to converting to binary, which is $(365)_{10} = (101101101)_2$

- Use 4-bit binary to represent one decimal digit
- Easy conversion
- Wasting bits (4-bits can represent 16 different values, but only 10 values are used). Clearly, BCD requires more bits. BUT, it is easier to understand/interpret

DECIMAL DIGIT	0	1	2	3	4	5	6	7	8	9
BCD	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001

- Thanks