

《计算机系统》

DataLab 实验报告

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1 实验项目二

1.1 项目名称

DataLab

1.2 实验目的

- 1) 补全 bits.c 中的 15 个函数
- 2) 熟练掌握 IEEE 浮点数表示

1.3 实验资源

- 1) bits.c- ★完成这个文件中的 15 个函数
- 2) bits.h- 头文件
- 3) btest.c- 主 btest 程序（用于测试结果）
- 4) btest.h,decl.c,tests.c,tests-header.c- 用于生成 btest
- 5) fshow.c-用于检查浮点表示的实用工具
- 6) ishow.c-用于检查整数表示的实用工具
- 7) dlc -编译器

2 实验任务

2.1 实验任务 A——补全 bits.c 中的函数

1) bitAnd

```

/*
 * bitAnd - x&y using only ~ and |
 *   Example: bitAnd(6, 5) = 4
 *   Legal ops: ~ |
 *   Max ops: 8
 *   Rating: 1
 */
int bitAnd(int x, int y) {
    //德摩根律，用按位或和按位取反实现按位与
    return ~(~x|~y);
}

baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ ./dlc bits.c/usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.

Compilation Successful (1 warning)
baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ make clean && make btest && ./btest -f bitAnd
rm -f *.o btest fshow ishow *-
gcc -O -Wall -lm -o btest bits.c btest.c decl.c tests.c
btest.c: In function 'main':
btest.c:528:9: warning: variable 'errors' set but not used [-Wunused-but-set-variable]
    int errors;
    ^
Score  Rating  Errors  Function
1       1       0      bitAnd
Total points: 1/1

```

其中输入./dlc bits.c 是有 warning 是正常的

Note: dlc will always output the following warning, which can be ignored:

/usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.

2) getByte

```

/*
 * getByte - Extract byte n from word x
 *   Bytes numbered from 0 (LSB) to 3 (MSB)
 *   Examples: getByte(0x12345678,1) = 0x56
 *   Legal ops: ! ~ & ^ | + << >>
 *   Max ops: 6
 *   Rating: 2
 */
int getByte(int x, int n) {
    //在x中提取第n个字节的值，n为0-3
    return (x >> (n << 3)) & 0xFF;
}

baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ ./dlc bits.c
/usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.

Compilation Successful (1 warning)
baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ make clean && make btest && ./btest -f getByte
rm -f *.o btest fshow ishow *-
gcc -O -Wall -lm -o btest bits.c btest.c decl.c tests.c
btest.c: In function 'main':
btest.c:528:9: warning: variable 'errors' set but not used [-Wunused-but-set-variable]
    int errors;
    ^
Score  Rating  Errors  Function
2       2       0      getByte
Total points: 2/2

```

3) logicalShift

```

/*
 * logicalShift - shift x to the right by n, using a
 * logical shift
 * Can assume that 0 <= n <= 31
 * Examples: logicalShift(0x87654321,4) = 0x08765432
 * Legal ops: ! ~ & ^ | + << >>
 * Max ops: 20
 * Rating: 3
 */
int logicalShift(int x, int n) {
    //实现逻辑右移, 左侧补充0
    //1<31变成100...00, 符号位变1,右移n位前面补1
    //再左移一位, 取反, 实现高位n位为0,其余为1
    int mask = ~(((1 << 31) >> n) << 1);
    return (x >> n) & mask;
}

```

baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout\$./dlc bits.c
 /usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.
 Compilation Successful (1 warning)
 baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout\$ make clean && make btest && ./btest -f logicalShift
 rm -f *.o btest fshow ishow *~
 gcc -O -Wall -lm -o btest bits.c btest.c decl.c tests.c
 btest.c: In function 'main':
 btest.c:528:9: warning: variable 'errors' set but not used [-Wunused-but-set-variable]
 int errors;
 ^
 Score Rating Errors Function
 3 3 0 logicalShift
 Total points: 3/3

4) bitCount

```

int bitCount(int x) {
    //求出x二进制中有多少个1
    //它首先将相邻的位对半加起来
    //然后再将相邻的两位组合成四位, 以此类推
    //直到整个字中每相邻的 16 位被相加
    //最后, 返回结果中的最后 6 位, 即为原始数中包含的 1 的个数
    int tempmask1 = 0x55 | (0x55 << 8);
    //得到掩码 01010101...01010101
    int mask1 = tempmask1 | (tempmask1 << 16);
    int tempmask2 = 0x33 | (0x33 << 8);
    //得到掩码 00110011...00110011
    int mask2 = tempmask2 | (tempmask2 << 16);
    int tempmask3 = 0x0f | (0x0f << 8);
    //得到掩码 00001111...00001111
    int mask3 = tempmask3 | (tempmask3 << 16);
    //得到掩码 0000 0000 1111 1111 0000 0000 1111 1111
    int mask4 = 0xff | (0xff << 16);
    //得到掩码: 0000 0000 0000 0000 1111 1111 1111 1111
    int mask5 = 0xff | (0xff << 8);
    //前后加起来
    x = (x & mask1) + ((x >> 1) & mask1);
    x = (x & mask2) + ((x >> 2) & mask2);
    x = (x & mask3) + ((x >> 4) & mask3);
    x = (x & mask4) + ((x >> 8) & mask4);
    x = (x & mask5) + ((x >> 16) & mask5);

    return x & 0xff;
}

```

baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout\$./dlc bits.c
 /usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.
 Compilation Successful (1 warning)
 baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout\$ make clean && make btest && ./btest -f bitCount
 rm -f *.o btest fshow ishow *~
 gcc -O -Wall -lm -o btest bits.c btest.c decl.c tests.c
 btest.c: In function 'main':
 btest.c:528:9: warning: variable 'errors' set but not used [-Wunused-but-set-variable]
 int errors;
 ^
 Score Rating Errors Function
 4 4 0 bitCount
 Total points: 4/4

5) bang

```

/*
 * bang - Compute !x without using !
 * Examples: bang(3) = 0, bang(0) = 1
 * Legal ops: ~ & ^ | + << >>
 * Max ops: 12
 * Rating: 4
 */
int bang(int x) {
    //如果 x 为零则返回1, 否则返回0
    //这里不用像上一题那样计算数量, 只需用'|'来保证有1就行了
    int or16, or8, or4, or2, or1;
    or16 = x | x >> 16;
    or8 = or16 | or16 >> 8;
    or4 = or8 | or8 >> 4;
    or2 = or4 | or4 >> 2;
    or1 = or2 | or2 >> 1;
    return (or1 & 0x01) ^ 0x01;
}

```

```

baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ ./dlc bits.c
/usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.

Compilation Successful (1 warning)
baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ make clean && make btest && ./btest -f bang
rm -f *.o btest fshow ishow *.~
gcc -O -Wall -ln -o btest bits.c btest.c decl.c tests.c
btest.c: In function 'main':
btest.c:528:9: warning: variable 'errors' set but not used [-Wunused-but-set-variable]
    int errors;
    ^
Score  Rating  Errors  Function
4      4        0      bang
Total points: 4/4

```

6) tmin

```

/*
 * tmin - return minimum two's complement integer
 * Legal ops: ! ~ & ^ | + << >>
 * Max ops: 4
 * Rating: 1
 */
int tmin(void) {
    //返回补码表示的最小整数
    return 1 << 31;
}

```

```

baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ ./dlc bits.c
/usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.
dlc:bits.c:224:bang: Illegal operator (-)

Compilation Successful (1 warning)
baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ make clean && make btest && ./btest -f tmin
rm -f *.o btest fshow ishow *.~
gcc -O -Wall -ln -o btest bits.c btest.c decl.c tests.c
btest.c: In function 'main':
btest.c:528:9: warning: variable 'errors' set but not used [-Wunused-but-set-variable]
    int errors;
    ^
Score  Rating  Errors  Function
1      1        0      tmin
Total points: 1/1

```

7) fitsBits

```

/*
 * fitsBits - return 1 if x can be represented as an
 * n-bit, two's complement integer.
 * 1 <= n <= 32
 * Examples: fitsBits(5,3) = 0, fitsBits(-4,3) = 1
 * Legal ops: ! ~ & ^ | + << >>
 * Max ops: 15
 * Rating: 2
 */
int fitsBits(int x, int n) {
    //判断一个整数 x 是否可以用 n 位的补码表示
    //计算32-n
    int shift = 32 + (~n + 1);
    return !(((x << shift) >> shift) ^ x);
}

```

```

baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ ./dlc bits.c
/usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.

Compilation Successful (1 warning)
baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ make clean && make btest && ./btest -f fitsBits
rm -f *.o btest fshow ishow *.~
gcc -O -Wall -ln -o btest bits.c btest.c decl.c tests.c
btest.c: In function 'main':
btest.c:528:9: warning: variable 'errors' set but not used [-Wunused-but-set-variable]
    int errors;
    ^
Score  Rating  Errors  Function
2      2        0      fitsBits
Total points: 2/2

```

8) divpwr2

```

/*
 * divpwr2 - Compute x/(2^n), for 0 <= n <= 30
 * Round toward zero
 * Examples: divpwr2(15,1) = 7, divpwr2(-33,4) = -2
 * Legal ops: ! ~ & ^ | + << >>
 * Max ops: 15
 * Rating: 2
 */
int divpwr2(int x, int n) {
    //计算x/(2^n), 其中0 <= n <= 30
    //整数除法的性质: 当被除数和除数都为正数时, 结果向下取整;
    //当被除数和除数异号时, 结果向零取整
    //对于正数 x, 可以直接右移 n 位来实现除法
    //如果 x 为负, 我们需要先加上2^n - 1然后再右移 n 位。
    int sign = x >> 31;           // 获取符号位
    int bias = (1 << n) + ~0;      // 计算 2^n - 1
    return (x + (sign & bias)) >> n; // 根据符号位来调整结果
}

```

```

baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ ./dlc bits.c
/usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.

Compilation Successful (1 warning)
baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ make clean && make btest && ./btest -f divpwr2
rm -f *.o btest fshow ishow *~
gcc -O -Wall -lm -o btest bits.c btest.c decl.c tests.c
btest.c: In function 'main':
btest.c:528:9: warning: variable 'errors' set but not used [-Wunused-but-set-variable]
    int errors;
        ^
Score  Rating  Errors  Function
  2      2      0      divpwr2
Total points: 2/2

```

9) negate

```

/*
 * negate - return -x
 * Example: negate(1) = -1.
 * Legal ops: ! ~ & ^ | + << >>
 * Max ops: 5
 * Rating: 2
 */
int negate(int x) {
    //计算-x
    return ~x + 1;
}

```

```

baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ ./dlc bits.c
/usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.

Compilation Successful (1 warning)
baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ make clean && make btest && ./btest -f negate
rm -f *.o btest fshow ishow *~
gcc -O -Wall -lm -o btest bits.c btest.c decl.c tests.c
btest.c: In function 'main':
btest.c:528:9: warning: variable 'errors' set but not used [-Wunused-but-set-variable]
    int errors;
        ^
Score  Rating  Errors  Function
  2      2      0      negate
Total points: 2/2

```


10) isPositive

```

int isPositive(int x) {
    //判断x是否大于0
    //x >> 31 是获取 x 的符号位
    //!x 是判断 x 是否为 0
    return !((x >> 31) | !x);
}
/*
 * isLessOrEqual - if x <= y then return 1, else return 0
 * Example: isLessOrEqual(4,5) = 1.
 * Legal ops: ! ~ & ^ | + << >>
 * Max ops: 24
 * Rating: 3
 */

```

```

baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ ./dlc bits.c
/usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.

Compilation Successful (1 warning)
baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ make clean && make btest && ./btest -f isPositive
rm -f *.o btest fshow ishow *~
gcc -O -Wall -lm -o btest bits.c btest.c decl.c tests.c
btest.c: In function 'main':
btest.c:528:9: warning: variable 'errors' set but not used [-Wunused-but-set-variable]
    int errors;
        ^
Score   Rating  Errors  Function
   3       3      0      isPositive
Total points: 3/3

```

11) isLessOrEqual

```

int isLessOrEqual(int x, int y) {
    //判断 x 是否小于等于 y
    //考虑两种情况:
    //一种是 x 和 y 同号, 此时只需比较它们的差是否小于等于 0;

    //另一种是 x 和 y 异号, 此时只需判断 x 的符号位
    int signX = x >> 31 & 1; // x 的符号位
    int signY = y >> 31 & 1; // y 的符号位
    int signEqual = !(signX ^ signY); // x和y的符号是否相同
    int diff = y + (~x + 1); // y - x
    //如果符号相同, 则只需判断即差值的符号位是否为1
    //如果符号不相同, 则只需判断 x 的符号位是否为 1
    return (signEqual & !(diff >> 31)) | ((!signEqual) & signX);
}

```

```

baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ ./dlc bits.c
/usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.

Compilation Successful (1 warning)
baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ make clean && make btest && ./btest -f isPositive
rm -f *.o btest fshow ishow *~
gcc -O -Wall -lm -o btest bits.c btest.c decl.c tests.c
btest.c: In function 'main':
btest.c:528:9: warning: variable 'errors' set but not used [-Wunused-but-set-variable]
    int errors;
        ^
Score   Rating  Errors  Function
   3       3      0      isPositive
Total points: 3/3

```


12) ilog2

```

/*
 * ilog2 - return floor(log base 2 of x), where x > 0
 * Example: ilog2(16) = 4
 * Legal ops: ! ~ & ^ | + << >>
 * Max ops: 90
 * Rating: 4
 */
int ilog2(int x) {
    //计算一个正数 x 的以 2 为底的对数
    //如果 x 的最高位在第 n 位, 则返回的结果为 n
    //可以从高位开始逐渐检查每个位, 找到最高位的位置
    //这可以通过先将 x 右移一半的位数
    //然后不断将右移的位数减半来实现

    int shift = 0;
    // 判断最高 16 位是否有值, 并将结果左移 4 位
    shift = (x >> 16) << 4;
    // 判断最高 8 位是否有值, 并将结果左移 3 位
    shift = shift + ((x >> (shift + 8)) << 3);
    // 判断最高 4 位是否有值, 并将结果左移 2 位
    shift = shift + ((x >> (shift + 4)) << 2);
    // 判断最高 2 位是否有值, 并将结果左移 1 位
    shift = shift + ((x >> (shift + 2)) << 1);
    // 判断最高 1 位是否有值
    shift = shift + ((x >> (shift + 1)) << 1);
    return shift;
}

```

```

baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ ./dlc bits.c
/usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.

Compilation Successful (1 warning)
baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ make clean && make btest
rm -f *.o btest fshow ishow *~
gcc -O -Wall -lm -o btest bits.c btest.c decl.c tests.c
btest.c: In function 'main':
btest.c:528:9: warning: variable 'errors' set but not used [-Wunused-but-set-variable]
    int errors;
    ^
Score  Rating  Errors  Function
  4      4      0      ilog2
Total points: 4/4

```

13) float_neg

```

/*
 * float_neg - Return bit-level equivalent of expression -f
 * for floating point argument f.
 * Both the argument and result are passed as unsigned
 * int's, but they are to be interpreted as the bit-level
 * representations of
 * single-precision floating point values.
 * When argument is NaN, return argument.
 * Legal ops: Any integer/unsigned operations incl. ||, &&,
 * also if, while
 * Max ops: 10
 * Rating: 2
 */
unsigned float_neg(unsigned uf) {
    //返回浮点数 f 的相反数的位级表示
    //如果 f 是 NaN (非数字), 则返回 f 本身的位级表示
    unsigned exp = (uf >> 23) & 0xFF; // 提取指数域
    unsigned frac = uf & 0x7FFFFF; // 提取尾数域
    // 如果指数域全为 1 且尾数域不全为 0, 则为 NaN, 直接返回 uf
    if (exp == 0xFF && frac != 0) {
        return uf;
    }
    // 取反符号位得到相反数的位级表示
    return uf ^ 0x80000000;
}

```

```

baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ ./dlc bits.c
/usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.

Compilation Successful (1 warning)
baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ make clean && make btest
rm -f *.o btest fshow ishow *~
gcc -O -Wall -lm -o btest bits.c btest.c decl.c tests.c
btest.c: In function 'main':
btest.c:528:9: warning: variable 'errors' set but not used [-Wunused-but-set-variable]
    int errors;
    ^
Score  Rating  Errors  Function
  2      2      0      float_neg
Total points: 2/2

```

14) float_i2f

```

unsigned float_i2f(int x) {
    int s;
    int exp;
    int frac;
    int ans;
    int front_zero_cnt;
    int low_9;

    if (x == 0) return 0;
    if (x == 0x80000000) return 0xc0000000; // 负零的位级表示

    s = x & 0x80000000; // 提取符号位
    if (x < 0) x = -x; // 将输入的整数变成正数

    front_zero_cnt = 0;
    while (!(x & 0x08000000)) {
        front_zero_cnt++;
        x = x << 1;
    }

    exp = (127 + 32 - front_zero_cnt - 1) << 23; // 计算指数部分

    x = x << 1; // 去除尾数省略的那个 1
    frac = x >> 9 & 0x007fffff; // 提取尾数部分

    ans = s + exp + frac;

    low_9 = x & 0x000001ff; // 低 9 位
    if (low_9 > 0x00000100) ans++; // 进位
    if ((low_9 == 0x00000100) && (ans & 0x1)) ans++; // 检查是否需要额外的进位

    return ans;
}

```

```

baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ ./dlc bits.c
/usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.

Compilation Successful (1 warning)
baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ make clean && make btest && ./btest -f float_i2f
rm -f *.o btest fshow ishow *~
gcc -O -Wall -lm -o btest bits.c btest.c decl.c tests.c
btest.c: In function 'main':
btest.c:528:9: warning: variable 'errors' set but not used [-Wunused-but-set-variable]
    int errors;
        ^
Score  Rating  Errors  Function
   4      4      0    float_i2f
Total points: 4/4

```

15) float_twice

```

211 for
* floating point argument f.
* Both the argument and result are passed as unsigned
int's, but
* they are to be interpreted as the bit-level
representation of
* single-precision floating point values.
* When argument is NaN, return argument
* Legal ops: Any integer/unsigned operations incl. ||, &&.
also if, while
* Max ops: 30
* Rating: 4
*/
unsigned float_twice(unsigned uf) {
    //计算浮点数 f 的两倍, 并返回其位级表示
    unsigned sign = uf & 0x80000000;    // 符号位
    unsigned exp = uf & 0x7F800000;    // 指数域
    unsigned frac = uf & 0x7FFFFF;    // 尾数域
    // 如果 f 是正无穷大或负无穷大, 直接返回 f 的位级表示
    if (exp == 0x7F800000) {
        return uf;
    }
    // 如果 f 是 NaN, 直接返回 f 的位级表示
    if (exp == 0x7F800000 && frac != 0) {
        return uf;
    }
    //非规格化数, 从尾数左移, 把移出来的1放到阶码上
    if (exp == 0) {
        uf = uf << 1;
        uf = uf + sign;
    }
    //规格化数 // 阶码 + 1
    else uf += 0x00800000;
    return uf;
}

```

```

baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ ./dlc bits.c
/usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.

Compilation Successful (1 warning)
baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ make clean && make btest
rm -f *.o btest fshow ishow *~
gcc -O -Wall -lm -o btest bits.c btest.c decl.c tests.c
btest.c: In function 'main':
btest.c:528:9: warning: variable 'errors' set but not used [-Wunused-but-set-variable]
    int errors;
    ^
Score   Rating  Errors  Function
4       4       0      float_twice
Total points: 4/4

```

3 总结

3.1 实验中遇到的问题

- 1) 第一次编译检测时出现未知 warning:

```
baijue@baijue-VirtualBox:~/桌面/CS_codes/datalab-handout$ ./dlc bits.c
/usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.
Compilation Successful (1 warning)
```

后查询官方网站得知此 warning 是正常的，可忽略

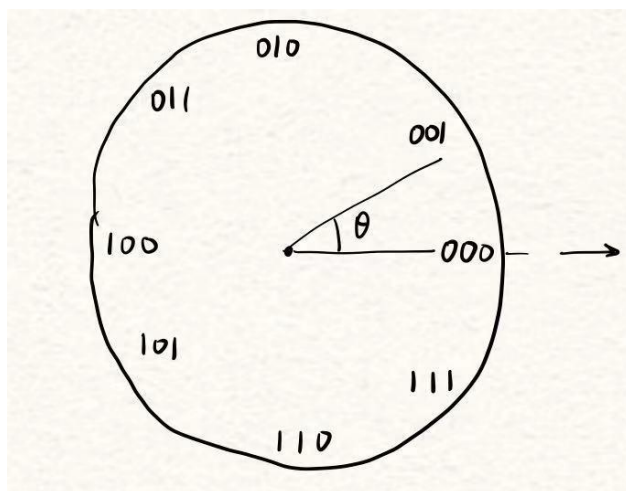
Note: dlc will always output the following warning, which can be ignored:

/usr/include/stdc-predef.h:1: Warning: Non-includable file <command-line> included from includable file /usr/include/stdc-predef.h.

- 2) 为什么补码 100 表示-4:

自衔的蛇: 计算机表示数字有着位数限制, 000 增大逐渐变成 111, 而 111 再增大就会溢出成为 000。这就像一头自衔其尾的蛇, 不能用数轴表示编码的逻辑关系, 应当用某种循环的结构表示编码之间的逻辑关系。

编码-角度: 而旋转符合这种逻辑关系, 旋转 0° 和旋转 360° 的效果是一样的。那么, 我们可以用角度描述编码的这种循环关系, 我们用角度对应相应的编码 (如下图所示)。



3.2 心得体会

- 1) 对浮点数在计算机中的**储存方式、舍入标准、实现、位运算**有了更深的掌握和理解；
- 2) 对分治法有了更深入的认识，可以熟练掌握运用；