Chapter - 11
Bit operations

Binary Numbers

Almost all machines organize their memory into 8 bit bytes. This means that a single location can hold 8 binary digits (bits) such as: `01100100`

Hex	Binary	Hex	Binary
0	0000	8	1000
1	0001	9	1001
2	0010	A	1010
3	0011	B	1011
4	0100	C	1100
5	0101	D	1101
6	0110	E	1110
7	0111	F	1111

Example: 0xAF = 1010 1111(binary).

Bit Operators

Operator	Meaning
&	Bitwise and
|	Bitwise or
^	Bitwise exclusive or
~	Complement
<<	Shift left
>>	Shift right

The and operator (&)

Bit 1	Bit 2	Bit1 & Bit2
0	0	0
0	1	0
1	0	0
1	1	1

The output of this program is:

```
Result of 45 & 71 = 41
```

	c1 = 0x45	binary 01000101
&	c2 = 0x71	binary 01110001
=	0x41	binary 01000001

"and" example

```
inline int even(const int value)
{
    return ((value & 1) == 0);
}
```

The difference between "and" (&) and "and and" (&&)

```
main()
{




}
```

Bitwise or (|)

Bit 1	Bit 2	Bit1 | Bit2
0	0	0
0	1	1
1	0	1
1	1	1

	i1=0x4 7	0100011 1
	i2=0x5 3	0101001 1
|	57	0101011 1

Bitwise exclusive Or (^)

Bit 1	Bit 2	Bit1 ^ Bit2
0	0	0
0	1	1
1	0	1
1	1	0

	0x47	01000111
	0x53	01010011
^	0x14	00010100

One's Complement / Not (~)

Bit 1	~Bit1
0	1
1	0

	0x47	01000111
~	0xB8	10111000

The Left and Right Shift Operators (<<, >>)

	c=0x1 C	0001110 0
c << 1	c=0x38	00111000
c >> 2	c=0x07	00000111

Right Shift Details.

	signed char	**signed char**	**unsigned char**
Expression	9 >> 2	-8 >> 2	248 >> 2
Binary Value>> 2	$0000\ 1010_2$ >> 2	$1111\ 1000_2$ >> 2	$1111\ 1000_2$ >> 2
Result	??$00\ 0010_2$	??$11\ 1110_2$ >> 2	??$11\ 1110_2$ >> 2
Fill	Sign Bit (0)	Sign Bit (1)	Zero
Final Result (Binary)	$0000\ 0010_2$	$1111\ 1110_2$	$0011\ 1110_2$
Final Result (short int)	2	-2	62

Defining Bits

A byte is divided into 8 bits.
Example: 0xAF or 10101111 binary.

7	6	5	4	3	2	1	0
1	0	1	0	1	1	1	1

Suppose we want to define five flags and put them in a byte. We start by assigning each flag a bit.

Bit	Name
0	ERROR
1	FRAMING_ERRO R
2	PARITY_ERROR
3	CARRIER_LOST
4	CHANNEL_DOWN

Bit Values the hard way

Bit	Binary Value	Hex Constant
7	10000000	0x80
6	01000000	0x40
5	00100000	0x20
4	00010000	0x10
3	00001000	0x08
2	00000100	0x04
1	00000010	0x02
0	00000001	0x01

Bit Values the Easy Way

C++ Representation	Base 2 Equivalent	Result (Base 2)	Bit Number
1<<0	00000001_2 << 0	00000001_2	Bit 0
1<<1	00000001_2 << 1	00000010_2	Bit 1
1<<2	00000001_2 << 2	00000100_2	Bit 2
1<<3	00000001_2 << 3	00001000_2	Bit 3
1<<4	00000001_2 << 4	00010000_2	Bit 4
1<<5	00000001_2 << 5	00100000_2	Bit 5
1<<6	00000001_2 << 6	01000000_2	Bit 6
1<<7	00000001_2 << 7	10000000_2	Bit 7

Setting, Testing and Clearing a bit

Setting

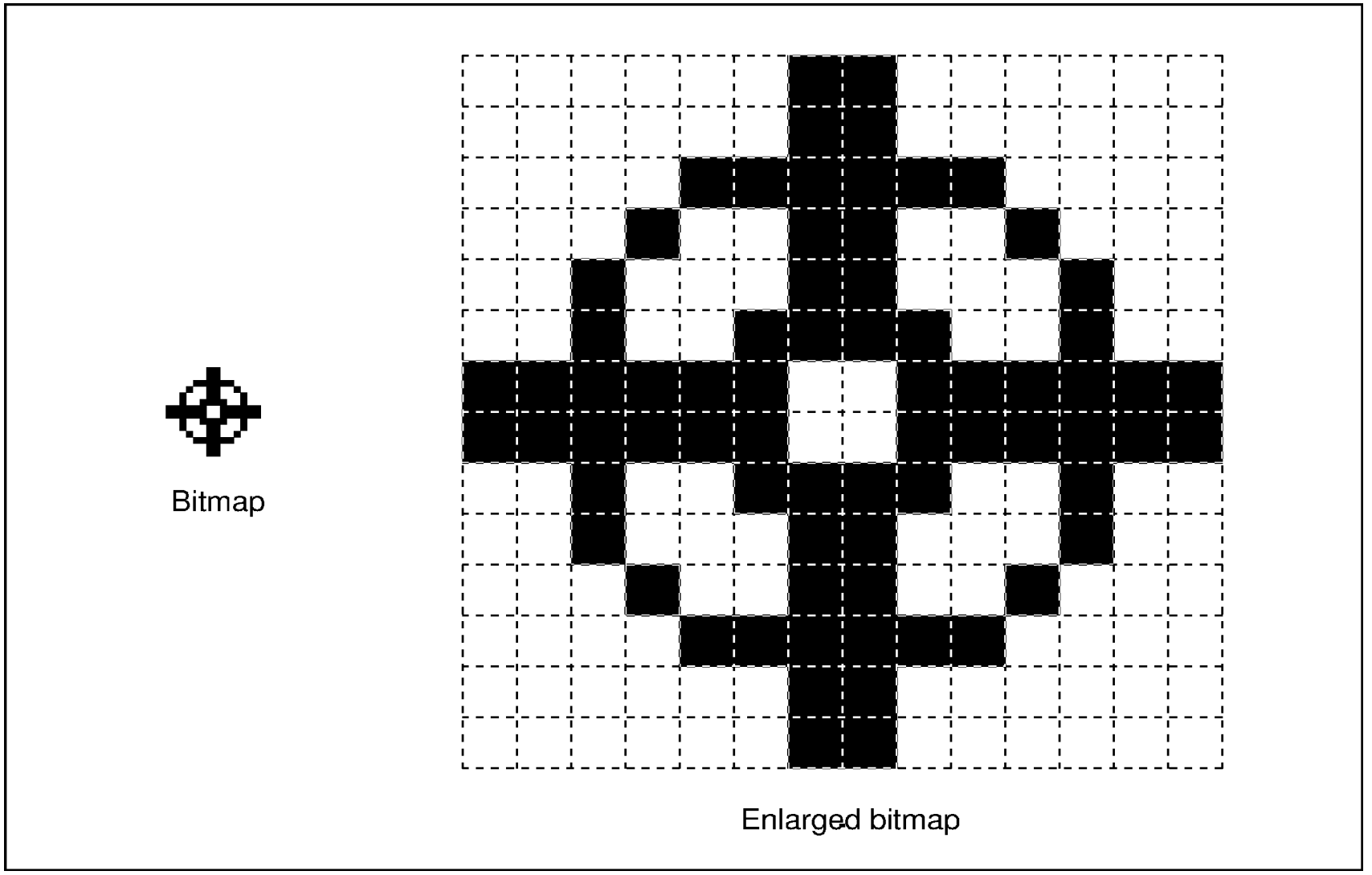
Testing

```
    else
```

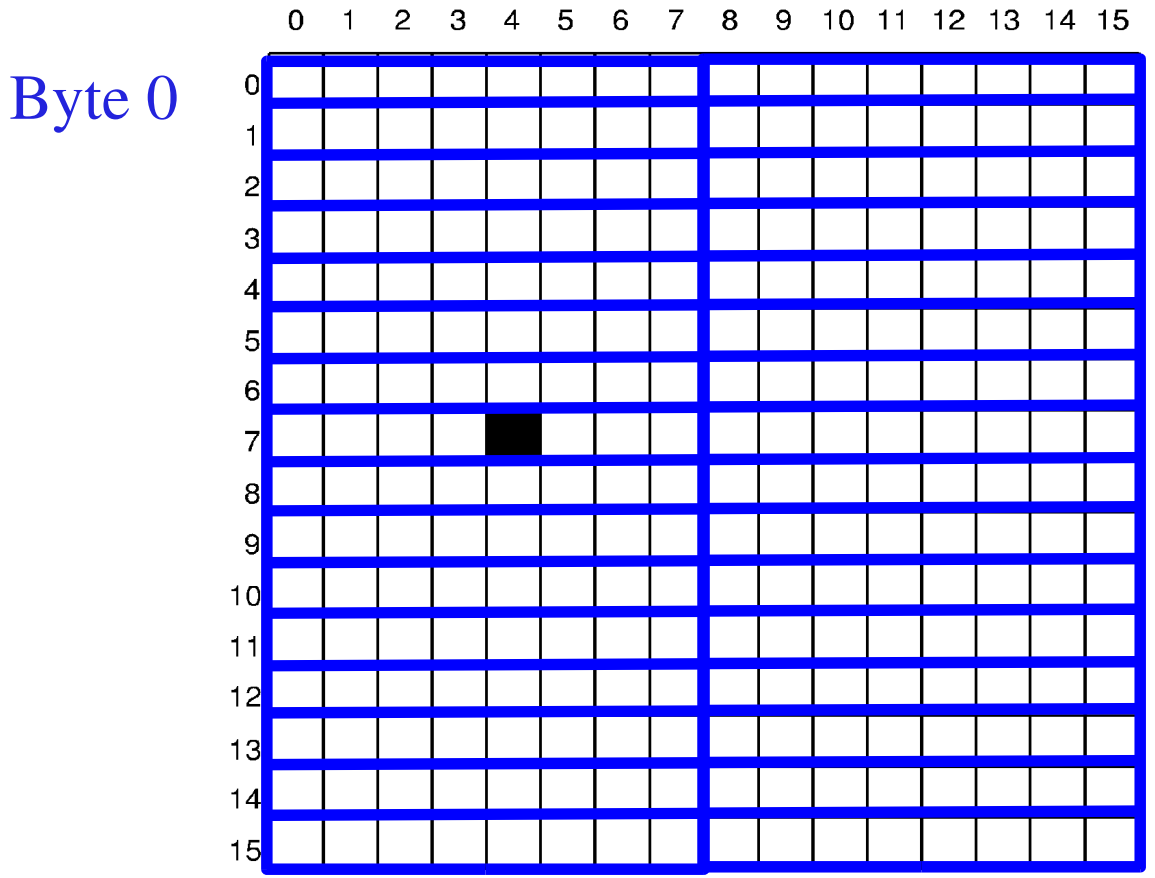
Clearing

`PARITY_ERROR`	00000100
`~PARITY_ERROR`	11111011
`flags`	00000101
`flags & ~PARITY_ERROR`	00000001

Bitmapped Graphics



Setting a bit in a 16 by 16 bitmap



Pixel (4,7) set in a 16x16 array of bits

Array of Bytes

```
bit_array[0][7] |= (0x80 >> (4));
```

Bit addressing

Translating (X,Y) from a bit address to a byte address.
X needs to get turned into a byte, bit pair.
X-Byte = X / 8 (8 bits per byte)

(Start with left most bit and shift over one for each bit needed.)

Y translates directly (that was easy)
C++ Version:

```
void inline set_bit(const int x,const int y)
  {

  }
```

```
/*

 */

/**************************************************************



 **************************************************************/


}
main(){



    print_graphics();

}
```

```
/**************************************************************

 **************************************************************/
{









                    else

                }
            }

        }
}
```

One loop works, the other doesn't. Why?

```
main()
{




     }




     }

}
```