

## 06 – ARITHMETIC

COMP256 – COMPUTING ABSTRACTIONS

DICKINSON COLLEGE

### BINARY ADDITION

$$\begin{array}{r} 1001 \ 0110 \\ + 0011 \ 0011 \\ \hline \end{array}$$

### BINARY ADDITION

$$\begin{array}{r} 11 \ 11 \\ 1001 \ 0110 \\ + 0011 \ 0011 \\ \hline 1100 \ 1001 \end{array}$$

Unsigned

Sign  
Magnitude

$$\begin{array}{r} -22 \\ + 51 \\ \hline -73 \end{array}$$

Two's  
Complement

### BINARY ADDITION

$$\begin{array}{r} 1010 \ 1101 \\ + 0110 \ 1001 \\ \hline \end{array}$$

• Did we get the right answer?

## BINARY ADDITION



Binary addition diagram:

$  \begin{array}{r}  111 \\  1010 \quad 1101 \\  + 0110 \quad 1001 \\  \hline  0001 \quad 0110  \end{array}  $	<b>Unsigned</b> $173$ $+ 105$ $\hline$ $22$ <span style="color: red;">X</span>	<b>Sign Magnitude</b> $-45$ $+ 105$ $\hline$ $60$ <span style="color: red;">X</span>	<b>Two's Complement</b> $-83$ $+ 105$ $\hline$ $22$ <span style="color: green;">✓</span>
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Carry Out

- What's different?

- The Carry Out is the value that is carried out from adding the MSbits of a binary addition.

## SO WHEN WILL THE RESULT BE CORRECT/INCORRECT?

- Google Doc On Moodle
  - Collaborative Documents
  - 06 – Arithmetic

## HARDWARE AND LANGUAGES

- Computer hardware and (most) computer languages use a fixed number of bits, called the *width of the data type*, to represent a value.

Java Type:	C/C++ Type:	Width:
byte	char	8 bits
short	short int	16 bits
int	int	32 bits
long	long int	64 bits

- The carry out bit is always discarded.

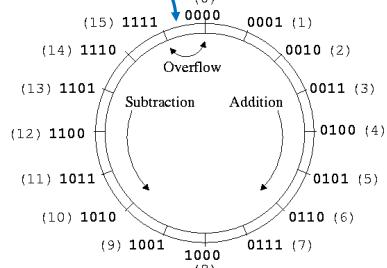
- Java uses two's complement for all whole number data types.
- C/C++ uses two's complement for signed types and unsigned for unsigned types.
  - `short int x = -1293;` // 2's complement
  - `unsigned short int x = 23179;` // unsigned

## CARRY OUT AND OVERFLOW

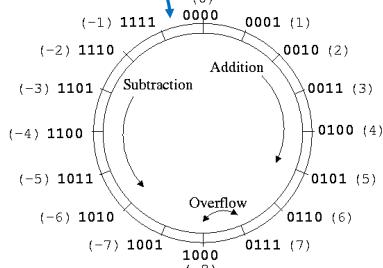
- The Carry Out is the value that is carried out from adding the MSbits of a binary addition.
- Overflow occurs when result of the operation is too large (or too small) to be held in the given number of bits in the representation.
  - Unsigned: A carry out of 1 indicates overflow.
  - Two's Complement: Overflow occurs when:
    - A positive plus a positive gives a negative result.
    - A negative plus a negative gives a positive result.

## SO WHAT'S HAPPENING?

### 4-bit Unsigned Binary



### 4-bit Two's Complement



## HOW PSY BROKE THE INTERNET

### PSY - GANGNAM STYLE (강남스타일) M/V



### PSY - GANGNAM STYLE (강남스타일) M/V



## IT CAN GET SERIOUS...

US aviation authority: Boeing 787 bug could cause 'loss of control'

More trouble for Dreamliner as Federal Aviation Administration warns glitch in control unit causes generators to shut down if left powered on for 248 days



248 days == 2<sup>31</sup> 100ths of a second.  
even in 2015, our airplanes have integer overflow bugs  
twitter.com/bengoldberg/  
ben goldberg @berggoldberg  
If you leave your Boeing 787 switched on for 248 days the power  
shuts off and you fall out of the sky Epic bug.  
theguardian.com/business/2015/...