

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

$$\begin{array}{r} 150 \\ + 51 \\ \hline 201 \checkmark \end{array}$$

Sign
Magnitude

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

Two's
Complement

BINARY ADDITION

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

• Did we get the right answer?

BINARY ADDITION



$$\begin{array}{r}
 \text{Unsigned} \\
 \begin{array}{r}
 \begin{array}{r}
 \text{Sign} \\
 \text{Magnitude}
 \end{array}
 \quad \begin{array}{r}
 \text{Two's} \\
 \text{Complement}
 \end{array}
 \end{array}
 \\[10pt]
 \begin{array}{r}
 1010 \ 1101 \\
 + 0110 \ 1001 \\
 \hline
 0001 \ 0110
 \end{array}
 \quad \begin{array}{r}
 173 \\
 + 105 \\
 \hline
 22 \text{ X}
 \end{array}
 \quad \begin{array}{r}
 -45 \\
 + 105 \\
 \hline
 22 \text{ X}
 \end{array}
 \quad \begin{array}{r}
 -83 \\
 + 105 \\
 \hline
 22 \checkmark
 \end{array}
 \end{array}$$

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.

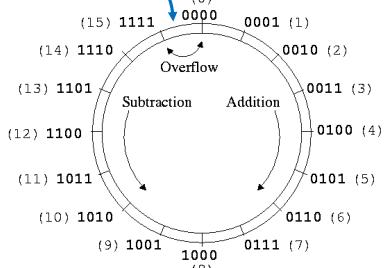
- Java uses two's complement for all whole number data types.
- C/C++ uses two's complement for signed types and unsigned for unsigned types.
 - `short int x = -1293;` // 2's complement
 - `unsigned short int x = 23179;` // unsigned

CARRY OUT AND OVERFLOW

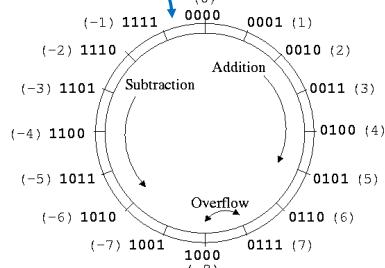
- The Carry Out is the value that is carried out from adding the MSbits of a binary addition.
- Overflow occurs when result of the operation is too large (or too small) to be held in the given number of bits in the representation.
 - Unsigned: A carry out of 1 indicates overflow.
 - Two's Complement: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

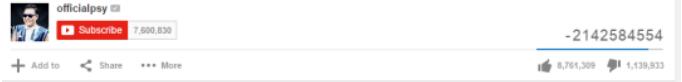


4-bit Two's Complement



THAT TIME PSY BROKE THE INTERNET

PSY - GANGNAM STYLE (강남스타일) M/V



PSY - GANGNAM STYLE (강남스타일) M/V



IT CAN GET SERIOUS...

US edition ·
The
Guardian

Search ·
Samuel Gibbs
Fri 1 May 2015 06.35 EDT
1,094 199

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



Fiona @fionakatema 248 days == 2³¹ 100ths of a second. even in 2015, our airplanes have integer overflow bugs! [@bengoldberg](http://twitter.com/bengoldberg)

ben goldberg @bengoldberg 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/...](http://theguardian.com/business/2015/)