

Unsigned Binary Addition

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These slides introduce unsigned binary addition

Unsigned Binary Addition

- Decimal Addition - Elementary school concepts
 - Add columns of numbers and keep track of the carry over to the next column
 - We normally use the decimal number system
 - Digits: 0-9
 - Carry over is in sets of 10

The diagram illustrates the process of adding 245 and 189 in three stages:

Stage 1: Initial numbers:
$$\begin{array}{r} 245 \\ + 189 \\ \hline \end{array}$$

Stage 2: First carry (9 + 9 = 18):
$$\begin{array}{r} 245 \\ + 189 \\ \hline 14 \end{array}$$

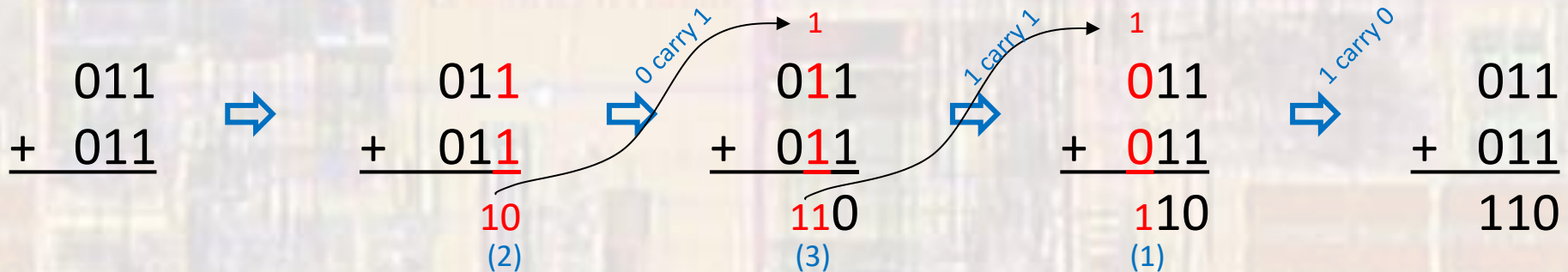
A curved arrow points from the '14' to the next stage, and a blue arrow points to the right.

Stage 3: Final result (1 + 13 = 14, carry 1 to the hundreds place):
$$\begin{array}{r} 1 \\ 245 \\ + 189 \\ \hline 434 \end{array}$$

A curved arrow points from the '1' to the next stage, and a blue arrow points to the right.

Unsigned Binary Addition

- Unsigned Binary Addition - Extend elementary school concepts
 - Add columns of numbers and keep track of the carry over to the next column
 - Use the binary number system
 - Digits: 0-1
 - Carry over is in sets of 2



Unsigned Binary Addition

- Unsigned Binary Addition - Examples

$$\begin{array}{r} \\ \\ \hline 100101 \\ + 011001 \\ \hline 111110 \end{array}$$

$$\begin{array}{r} \\ \\ \hline 101111 \\ + 001001 \\ \hline 111000 \end{array}$$

$$\begin{array}{r} \\ \\ \hline 101111 \\ + 011001 \\ \hline 1001000 \end{array}$$

Depending on the situation – this may or may not be a problem

Unsigned Binary Addition

- Overflow

- In elementary school we did not care how many digits the answer required

$$\begin{array}{r} 745 \\ + 589 \\ \hline 1334 \end{array}$$

- In unsigned binary addition – we are generally representing something that ultimately is to be executed in hardware
 - Our hardware cannot change the number of bits (wires) it can hold
 - We must establish a maximum number size (# of bits) and create an error when the result of the addition does not fit in this size
 - The error is called an **overflow**

6-bit numbers
6 wires for the result

$$\begin{array}{r} 11111 \\ 101111 \\ + 011001 \\ \hline 1001000 \end{array}$$

Unsigned Binary Addition

- Overflow – Unsigned Binary

add 101111 to 011001

8 bit unsigned binary

$$\begin{array}{r} 101111 \\ + 00011001 \\ \hline 01001000 \end{array}$$

No overflow

6 bit unsigned binary

$$\begin{array}{r} 11111 \\ + 011001 \\ \hline 1001000 \end{array}$$

Overflow

Unsigned Binary Addition

- Overflow – Interpretation

6 bit unsigned binary

$$\begin{array}{r} 101111 \\ + 011001 \\ \hline \cancel{1}001000 \end{array}$$

47
25
72

Overflow

72 does not fit in 6 bit unsigned

Result in 6 bits is 8

6 bit
Unsigned Binary
Number Line

