Chapter 03: Computer Arithmetic

Lesson 10

BCD Arithmetic Operations, Packed Decimals and Unpacked Decimals

Objective

- Understand the BCD
- BCD Numbers
- BCD Operations
- Packed Decimal
- Unpacked Decimal

BCD numbers

BCD Representation

- **Decimal 0 0d0**
- **BCD Representation 0000 0000 $_{bcd}$**

BCD Representation

- **Decimal 9 0d9**
- **BCD Representation 0000 1001_{bcd}**

BCD Representation

- **Decimal 10 0d10**
- **BCD Representation 0001 0000 $_{bcd}$**

BCD Representation

- **Decimal 12 0d12**
- **BCD Representation 0001 0010 $_{bcd}$**

BCD Representation

- **Decimal 85 0d85**
- **BCD Representation 1000 0105 $_{bcd}$**

The BCD representations of the decimal number 47 and binary number 0b01001000

- Decimal number 47 is denoted in BCD as 0d47 = $0100\ 0111_{bcd}$
- Binary number 0b01001000 = $2^6 + 2^3 = 64_d + 8_d$ = 0d72 = $0111\ 0010_{bcd}$

BCD operations

BCD arithmetic

- BCD arithmetic─ using binary arithmetic
- The results adjusted to obtain the BCD number

Example: Adding BCD numbers 0d89 and 0d22

- The BCD numbers 0d89 = $1000\ 1001_{bcd}$ and 0d22 = $0010\ 0010_{bcd}$
- Step 1
- First perform binary addition of BCD numbers, as if they were binary numbers
- Generate an auxiliary carry (AC) if the addition $(x_3 + y_3)$ at b_3 location caused a carry

Step 1

- $1000\ 1001_{bcd} + \underline{0010\ 0010_{bcd}} = \underline{1010\ 1011}$
- At bit 3, there is no carry, AC = 0

Step 2

- Perform the BCD adjust operation by adding 6 wherever required

Step 2 for adjusting the result of BCD addition in step 1

- 1000 1001_{bcd}
  + 0010 0010_{bcd}
  1010 1011
  0110 Add 6 because lower digit >9
  1010 0001 AC generated 1
  0001 so add 1 in the next digit
  1011 0001

Step 2

1011 0001

0110 Add 6 in upper digit as it is >0d9

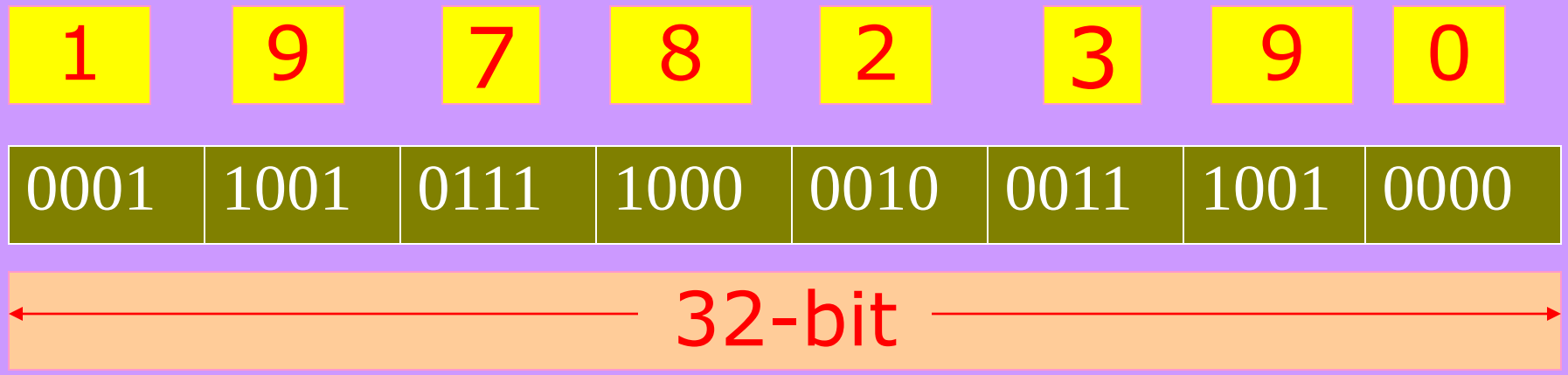
1 0001 0001 Carry from bit 7 = 1

This number represents 100010001bcd

and is answer 0d111

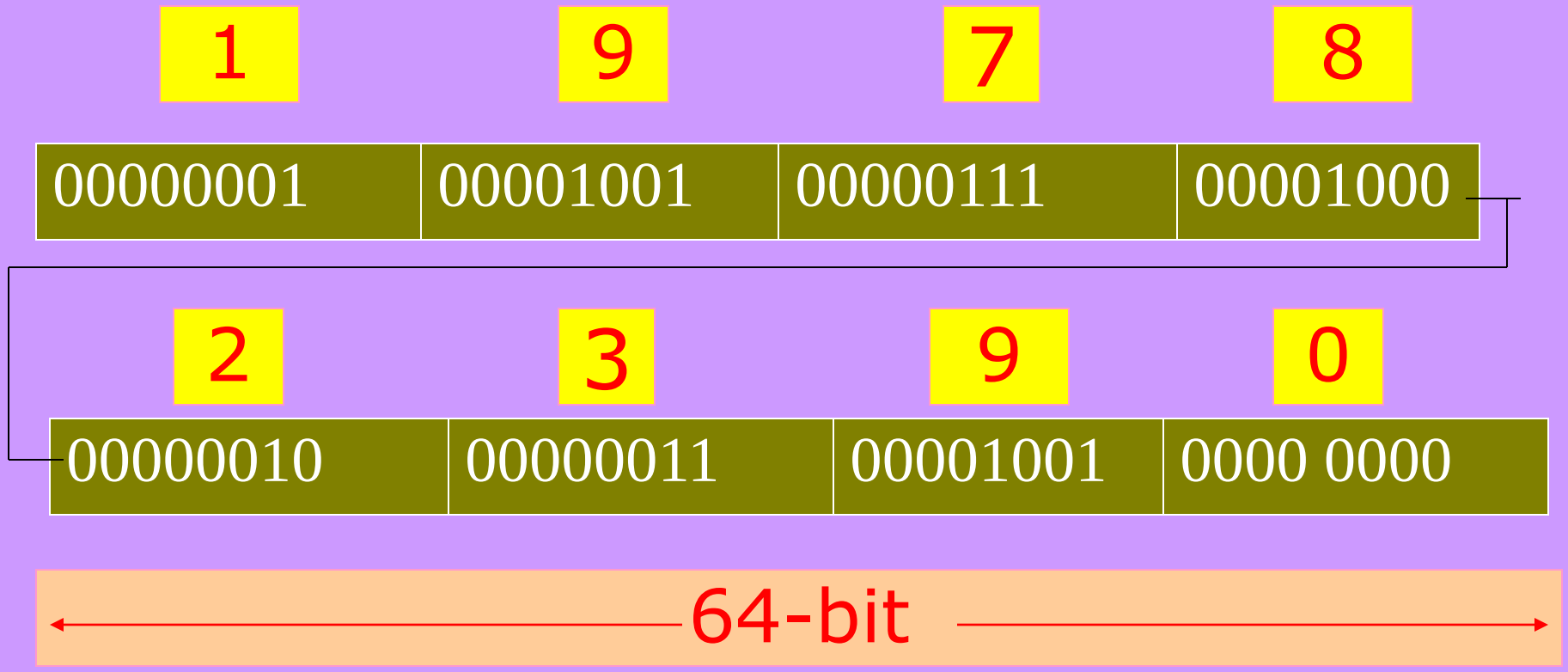
Packed Decimal

Example: Packing 19782390 in 32-bit memory



Unpacked Decimal

Example: Unpacking 19782390 in 32-bit memory as unpacked decimals



Summary

We learnt

- BCD Representation
- BCD Operations using AC
- Packed Decimal
- Unpacked Decimals

End of Lesson 10 on

BCD Arithmetic Operations, Packed Decimals and Unpacked Decimals