Unsigned Binary Numbers

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These slides introduce unsigned binary numbers

Unsigned Binary Numbers

- Unsigned Binary
  - Binary representation for numbers that are ALWAYS positive
    - Memory addresses
    - Counters
    - Populations
  - Often just called “binary”
  - Characterized by n-bits
    - E.g. Use a 16 bit unsigned binary number

Unsigned Binary Numbers

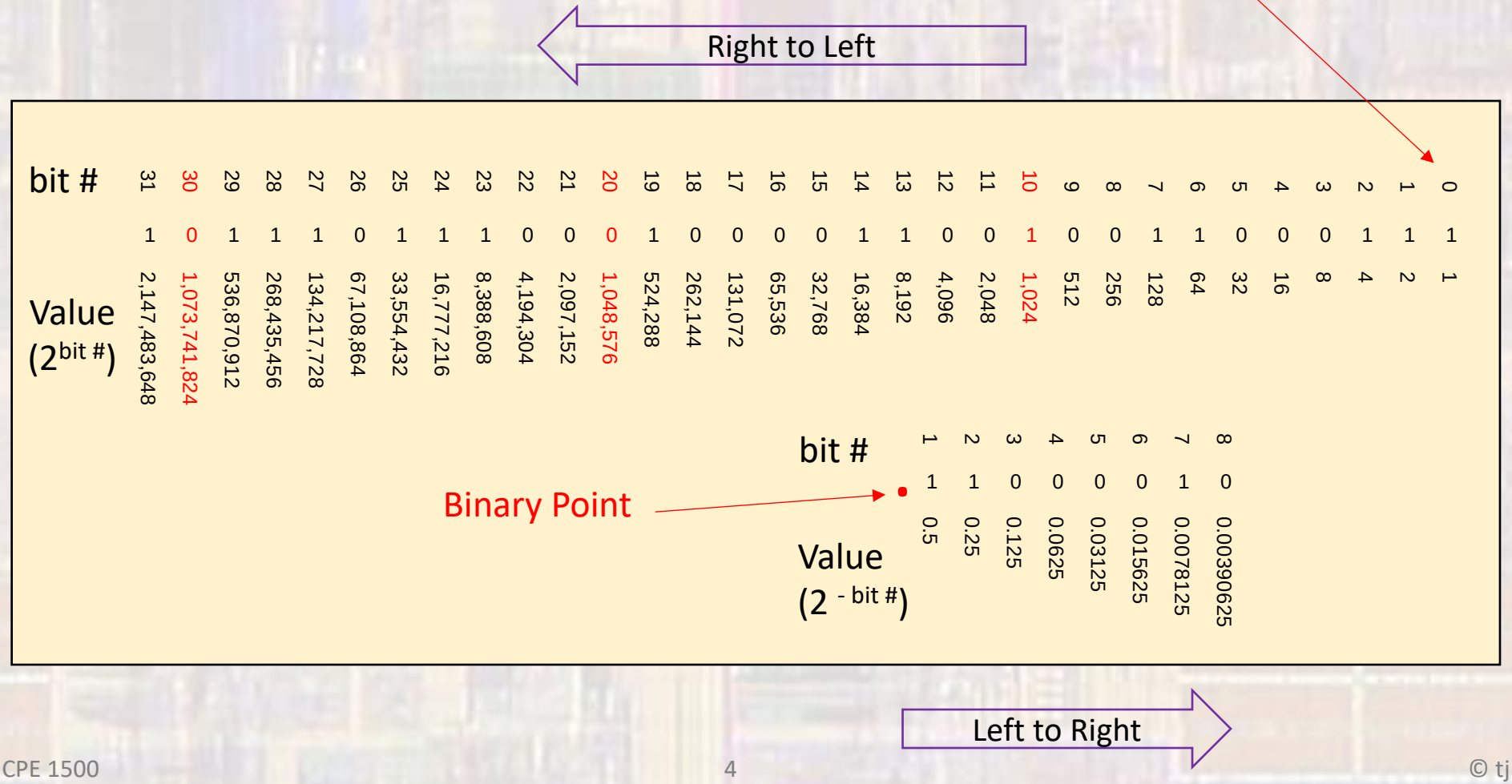
- Bit Values
  - All *n* bits used to represent the magnitude of the value
  - No negative values

4	→	00000100
32	→	00100000
16	→	00010000

Unsigned Binary Numbers

- Binary Bit Values

Note: we start counting bits at 0



Unsigned Binary Numbers

- Convert Unsigned Binary to Decimal
  - Process: identify the bits that are set to 1, multiply by the corresponding bit value, and sum them all together

convert 1010 unsigned binary to decimal

1010 → bit values: 8, 2 → 10

convert 11001 unsigned binary to decimal

11001 → bit values: 16, 8, 1 → 25

convert 1010101 unsigned binary to decimal

1010101 → bit values: 64, 16, 4, 1 → 85

Unsigned Binary Numbers

- Convert Unsigned Binary to Decimal – cont'd
  - Process: identify the bits that are set to 1, multiply by the corresponding bit value, and sum them all together

convert 1010.01 unsigned binary to decimal

1010.01 → bit values: 8, 2, ¼ → 10.25

convert 11001.101 unsigned binary to decimal

11001.101 → bit values: 16, 8, 1, ½, 1/8 → 25.625

convert 1010101.11 unsigned binary to decimal

1010101.11 → bit values: 64, 16, 4, 1, ½, ¼ → 85.75

Unsigned Binary Numbers

- Convert Decimal to Unsigned Binary
  - Process:
    1. Find the largest binary bit value that fits into the decimal number
    2. Write a 1
    3. Subtract that value from the decimal number and write down the remainder
    4. Check the next smallest binary bit value
       - If it fits in the remainder, write a 1
         Subtract that value from the decimal number and write down the remainder
         Repeat step 4
       - If it does not fit in the remainder, write a 0
         Repeat step 4

convert 50 decimal to unsigned binary

32 is the largest bit value that fits in 50

decimal value	50	18	2	2	2	0
bit value	1 (32)	1 (16)	0 (8)	0 (4)	1 (2)	0 (1)
remainder	18	2	2	2	2	2
Unsigned binary number	110010					

Unsigned Binary Numbers

- Convert Decimal to Unsigned Binary, cont'd
  - Process:
    1. Find the largest binary bit value that fits into the decimal number
    2. Write a 1
    3. Subtract that value from the decimal number and write down the remainder
    4. Check the next smallest binary bit value
       - If it fits in the remainder, write a 1
         Subtract that value from the decimal number and write down the remainder
         Repeat step 4
       - If it does not fit in the remainder, write a 0
         Repeat step 4

convert 88 decimal to unsigned binary

64 is the largest bit value that fits in 89

decimal value	89	25	25	9	1	1	1
bit value	1 (64)	0 (32)	1 (16)	1 (8)	0 (4)	0 (2)	1 (1)
remainder	225	25	9	1	1	1	0
Unsigned binary number	1011001						

Unsigned Binary Numbers

- Convert Decimal to Unsigned Binary, cont'd
  - Process:
    1. Find the largest binary bit value that fits into the decimal number
    2. Write a 1
    3. Subtract that value from the decimal number and write down the remainder
    4. Check the next smallest binary bit value
       - If it fits in the remainder, write a 1
         Subtract that value from the decimal number and write down the remainder
         Repeat step 4
       - If it does not fit in the remainder, write a 0
         Repeat step 4

convert 19.825 decimal to unsigned binary

16 is the largest bit value that fits in 19.825

dec value	19.825	3.825	3.825	3.825	0.825	0.825	0.325	.125
bit value	1 (16)	0 (8)	0 (4)	1 (2)	1 (1)	1 (.5)	1 (.25)	1 (0.125)1/8
remainder	3.825	3.825	3.825	1.825	0.825	.325	0.125	0

Unsigned binary number 10011.111

Unsigned Binary Numbers

- Convert Decimal to fixed size Unsigned Binary
  - Process:
    1. Find the largest binary bit value for the fixed sized unsigned binary number
       - If it fits in the remainder, write a 1
         Subtract that value from the decimal number and write down the remainder
       - If it does not fit in the remainder, write a 0
    2. Check the next smallest binary bit value
       - If it fits in the remainder, write a 1
         Subtract that value from the decimal number and write down the remainder
         Repeat step 4
       - If it does not fit in the remainder, write a 0
         Repeat step 4

128 is the largest bit value for an 8 bit unsigned binary value

decimal value	50	50	50	18	2	2	2	0
bit value	0 (128)	0 (64)	1 (32)	1 (16)	0 (8)	0 (4)	1 (2)	0 (1)
remainder	50	50	18	2	2	2	2	

Unsigned 8bit binary number 00110010

Unsigned Binary Numbers

- Word Length Extension
  - When extending to larger word sizes, add 0s to the left of the previous MSB

4 bit		8 bit		16 bit
0110	→	00000110	→	0000000000000110
1001	→	00001001	→	0000000000001001

Unsigned Binary Numbers

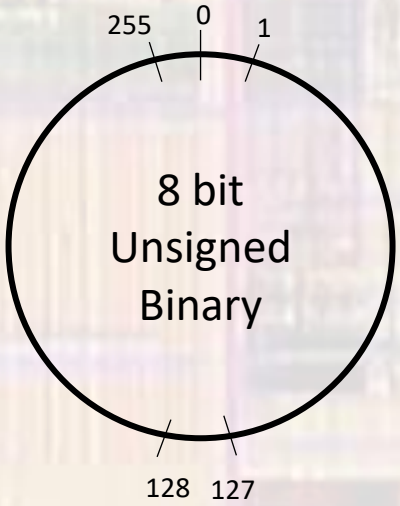
- Limits
  - Maximum values: (non fractional)
    - 4 bits (1111) = 15
    - 8 bits (1111 1111) = 255
    - 16 bits (1111 1111 1111 1111) = 65,535
    - 32 bits (1111 1111 1111 1111 1111 1111 1111 1111) = 4,294,967,295
  - Wait! 4 bits → 2^4 = 16, why is the maximum value 15

    8 bits → 2^8 = 256, why is the maximum value 255

    …

Unsigned Binary Numbers

- Number Lines
  - Fixed size limitations on binary numbers causes the number line to wrap around



1111	15
+ 0001	1
10000	0

11111111	255
+ 00000001	1
100000000	0

1111111111111111	65535
+ 0000000000000001	1
10000000000000000	0