CSARCH Lecture Series: Positional Number System

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Overview

Reflect on the following questions:

- How many unique symbols are there in quaternary (base-4) number system?
- What is the decimal equivalent of 0x2A7.8?

Overview

- This sub-module introduces the basic concept of positional* number system as well as how to convert from any number system to decimal.
- The objectives are as follows:
  - ✓Define what is positional number system
  - ✓Define the concepts of radix, place value and digit value
  - ✓Describe the process of converting from any number system to decimal

*positional also known as positional notation or place-value notation

Positional Number System

- The radix, or base, of a positional number system is the total number of unique symbols available in that system.
  - → denary/decimal number system, base/radix=10, 10 unique symbols
- The largest-valued symbol always has a magnitude of one less than the radix.
  - → denary/decimal: 0,1,2,3,4,5,6,7,8,9
- Symbols are usually digits starting from 0 to 9, alphabets A-Z and others.

Positional Number System

- Denary (or decimal) number system
  - Radix: 10
  - Unique symbols: 0,1,2,3,4,5,6,7,8,9
  - Denoted by subscript 10 (usually no subscript is assumed decimal)
  - example: 124.5_{10} or 124.5
- Binary number system
  - Radix: 2
  - Unique symbols: 0,1
  - Denoted by subscript 2 or prefix 0b or suffix b
  - example: 0101.1_2 or 0b0101.1 or 0101.1b

Positional Number System

- Octal number system
  - Radix: 8
  - Unique symbols: 0,1,2,3,4,5,6,7
  - Denoted by subscript 8, or prefix 0O or suffix O (both not recommended)
  - example: 67.4_8 or 0O67.4 or 67.4O (confusing!) or 0q67.4 or 67.4q
- Hexadecimal number system
  - Radix: 16
  - Unique symbols: 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F
  - Denoted by subscript 16 or prefix 0x or suffix h
  - example: $0A2.8_{16}$ or 0x0A2.8 or 0A2.8h

Try

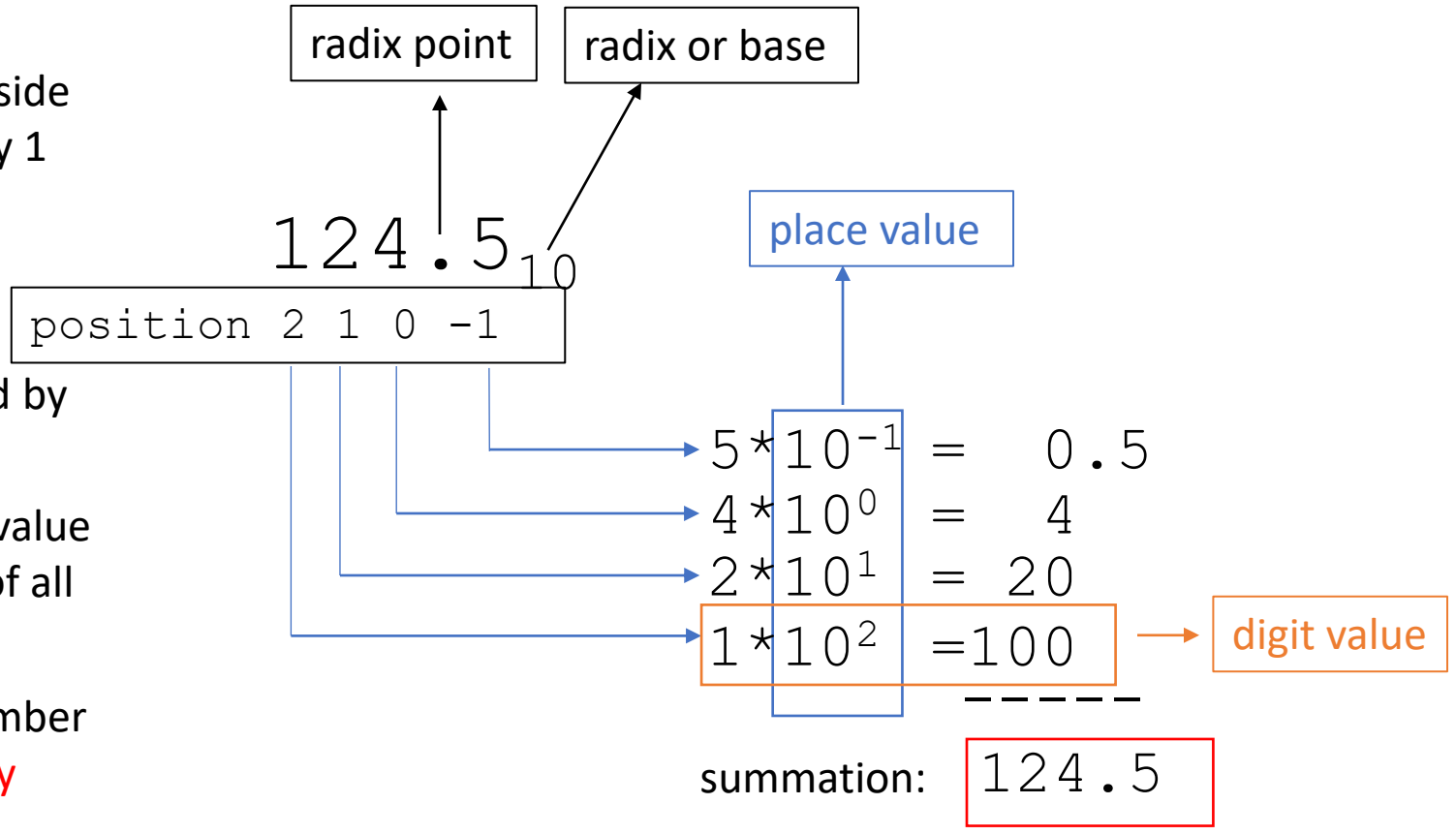
- For quaternary (base-4) number system
  - What is the radix?
  - What are the unique symbols?
  - How do you write a quaternary number system?

Try

- For quaternary (base-4) number system
  - What is the radix? 4
  - What are the unique symbols? 0,1,2,3
  - How do you write a quaternary number system? with subscript 4 (example: 23.1_4)

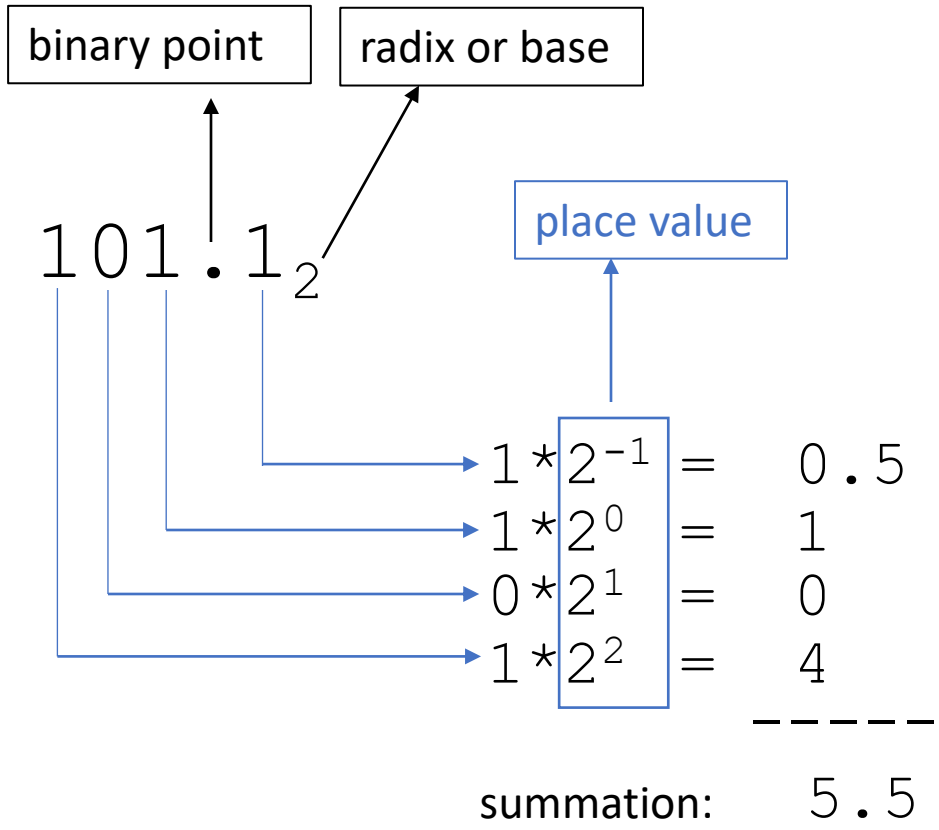
Positional Number System

- Position starts at 0 from the left side of the radix point and increment by 1 thereafter (i.e., 0,1,2,….)
- Position starts at -1 from the right side of the radix point and increment by 1 thereafter (i.e., 0,1,2,….)
- Place value is its base raised to its position
- A digit's value is the digit multiplied by its place value
- In positional number system, the value of the number is the summation of all digits' value
- Due to the nature of positional number system, it can be use to convert any base to decimal number system



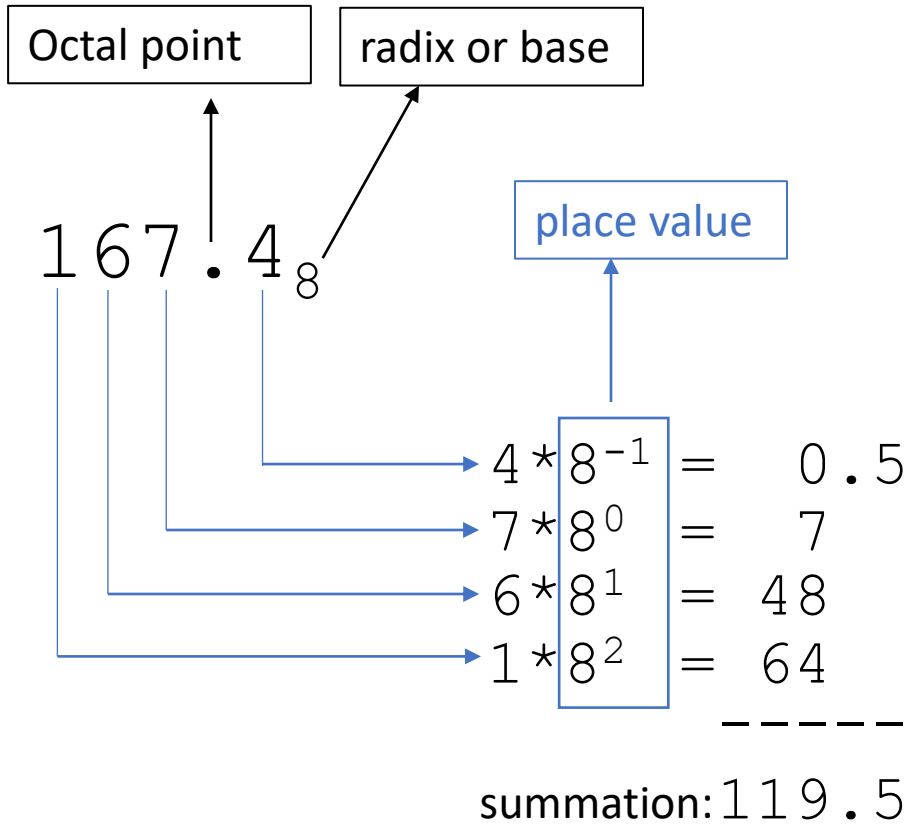
Positional Binary Number System

- In binary number system, the radix point is called binary point
- Note that in binary number system, the base of the place value is now 2 (i.e., 2^2, 2^1 ,2^0 , 2^{-1} ,etc.)



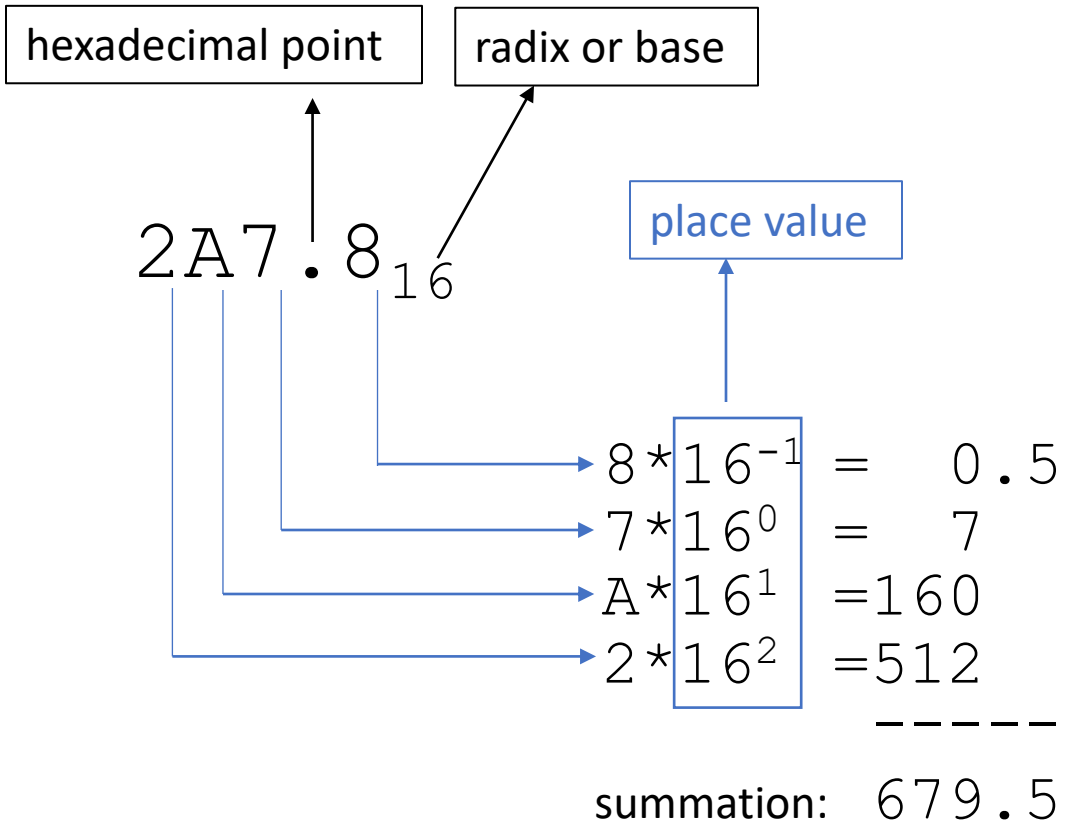
Positional Octal Number System

- In octal number system, the radix point is called octal point
- Note that in octal number system, the base of the place value is now 8 (i.e., 8^2, 8^1 ,8^0 , 8^{-1} ,etc.)



Positional Hexadecimal Number System

- In hexadecimal number system, the radix point is called hexadecimal point
- Note that in hexadecimal number system, the base of the place value is now 16 (i.e., 16^2, 16^1 ,16^0 , 16^{-1} ,etc.)



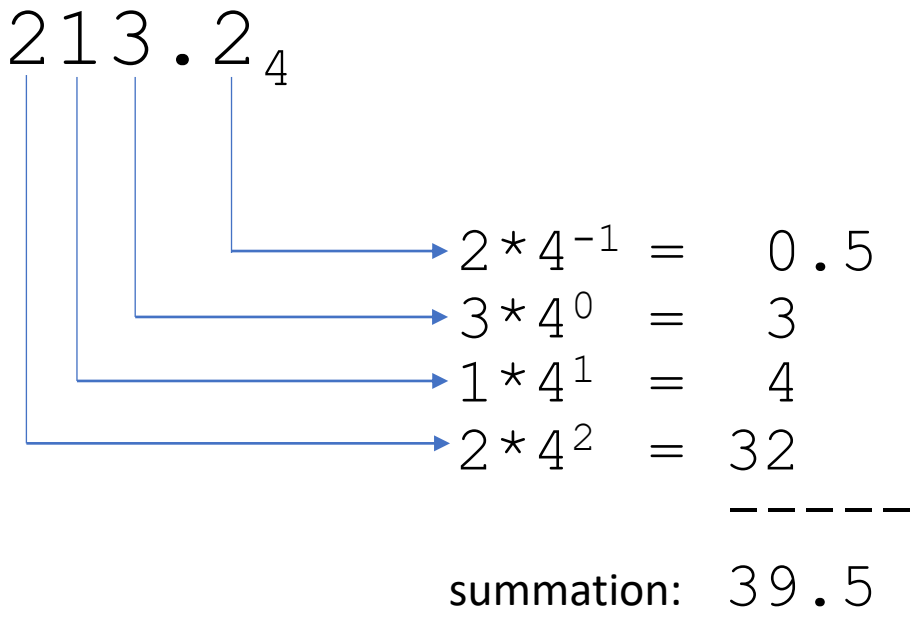
Try

213.2_4 = _____ $_{10}$

Try

213.2_4 = _____ $_{10}$

213.2_4 = 39.5 $_{10}$



Other Types of Positional Number System

Radix/Base	Number system	Radix/Base	Number System
1	Unary	2	Binary*
3	Ternary	4	Quatenary
5	Quinary	6	Senary
7	Septenary	8	Octal*
9	Nonary	10	Denary/Decimal*
11	Undecimal	12	Duodecimal
13	Tridecimal	14	Tetradecimal
15	Pentadecimal	16	Hexadecimal*
18	Octodecimal	20	Vigesimal
24	Tetravigesimal	25	Pentavigesimal

Other Types of Positional Number System

Radix/Base	Number system	Radix/Base	Number System
26	Hexavigesimal	27	Septemvigesimal
28	Octovigesimal	30	Trigesimal
32	Duotrigesimal	36	Hexatrigesimal
60	Sexagesimal	62	Duosexagesimal
64	Tetrasexagesimal	85	Pentaoctagesimal
120	Centovigesimal		
240	Duocentoquadragesimal		
360	Trecentosexagesimal		

To recall…

- What we have learned:
  - ✓Define what is positional number system
  - ✓Define the concepts of radix, place value and digit value
  - ✓Describe the process of converting from any number system to decimal