

11 Data Types & Type Systems

Thursday, October 22, 2020 9:24 AM

* Read chapter 7 from Scott
* Presentations on Monday.

→ values one can compute with in a program

- pre-defined/builtin types
- user-defined

→ Defining new types
Rules for type checking

What is a Data Type?

- Name
- values
- operations

Pre-defined types

- Numbers
 - integers
 - floating pt. numbers
 - Complex

- characters
- booleans
- enumerated types
- subrange types
- records / structs
- arrays
- strings
- sets
- hash tables / dictionaries
- lists
- files

• pointers

⇒ scalars
variable contains 1 value

⇒ Composite /
Aggregate Types

-
- * user-defined types
 - scalar
 - composite

11 Data Types - Basic Numeric Types

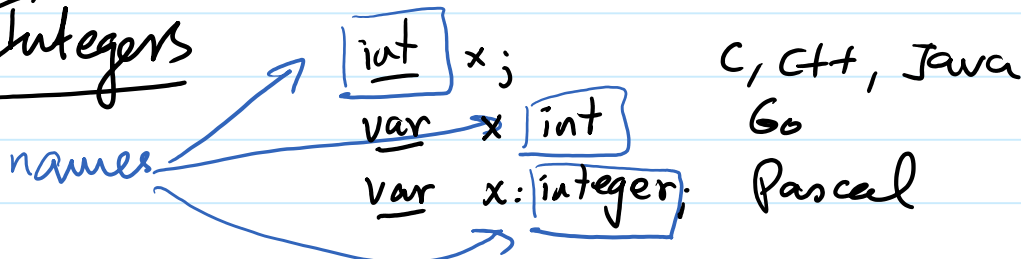
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- (1) What is the internal representation used?
- (2) What size is used to store a value?
- (3) What operations are available?
- (4) What happens if there is an overflow/underflow during compute?

Tension between the programming language definition + its implementation [Compiler/Interpreter]

Reference Manual

Integers



$+$, $-$, $*$, $/$, $\%$ (mod)

Python

$$a ** b = a^b$$

Representation:

$$(0101)_2 = (5)_{10}$$

2's complement

n bits

$$-2^{n-1} \dots 2^{n-1} - 1$$

16-bits

$$-2^{15} \dots 2^{15} - 1 \quad -32768 \dots 32767$$

$$x = 32767 + 1 \quad ? \rightarrow -32768$$



	C/C++	Java	Python	Go
unsigned	byte (8)	byte (8)	int	int8 vint8 \equiv byte
	short (16)	short (16)		int16 uint16
	int (32)	int (32)		int32 vint32 \equiv rune
	long (64)	long (64)		int64 vint64
	Integer, INT_MAX		unlimited	int (32) unit machine dependent

2 billion

base-2

2^{\sim}

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$\left. \begin{array}{l} + \text{ positive} \\ + \text{ issue} \\ + \text{ attack} \end{array} \right\} \text{ votes gained} = \text{positive} * 0.0005$
 1,000,000

1,000,000

$\boxed{+ \text{ positive} * \text{ issue} * \text{ attack} * 0.0001}$
 $- \text{ attack} * 0.0009$

$600,000 * 150,000 * 250,000$

$\underline{6} * 10^5 * \underline{1.5} * 10^5 * \underline{2.5} * 10^5 = \text{---} * 10^{15}$

int $2^{31}-1$ $2.1 * 10^9$

long

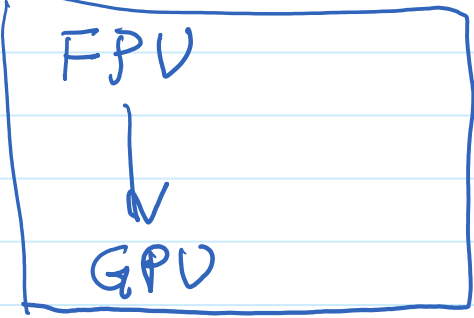
Floating Point Numbers

	<u>C, C++, Java</u>	<u>Python</u>	<u>Go</u>
+,-	float (32)	float	float32
*,/	double (64)	float	float64

All use the IEEE 754 Standard

16 32 64 128

Half single double



$a = 1.0/3;$ 0.3, 0.33, 0.3333333...

0.1

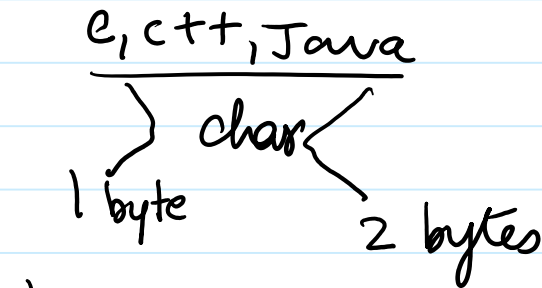
$(0.1 + 0.1 + 0.1 = 0.3)$

11 Data Types - Basic Types

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characters



Go

No type

byte 1
rune 4

+ , -

$$'A' + 3 = 'D'$$

65 68

Look up
char coding.

Booleans

<u>C</u>	<u>Java</u>	<u>Go</u>	<u>Python</u>
no	boolean false true	bool false true	bool False True
<stdbool.h>			
bool found;	&&	!	and or not

Complex

C, Go

var a complex
a = 10 + 2i