OPERATOR PRECEDENCE, DATA REPRESENTATION

Problem Solving with Computers-I

https://ucsb-cs16-wi17.github.io/

Announcements

- Lab02 – we have found an error in the last exercise (calculate approximate value for pi), please wait for further instructions via Piazza
- Midterm next week –Thursday (02/02)
- Study guide will be posted by tomorrow at this location: https://ucsb-cs16-wi17.github.io/exam/e01/
- Midterm will cover topics from
  - Lectures 1 to 7 (including code covered in class)
  - Labs 0 to 2
  - Homeworks 1 to 6

Note: Slides are not a replacement for the book

Review homework 4, problem 3

What is the output of the following program?

```
int x = 0;
while ( x = 2 && x < 10){
    cout << x << endl;
    x+=2;
}
```

// x = x+2;

Boolean expression

either evaluates to a true or false

0 means false

Anything else is true !

A. Nothing is printed to output [Mistook assignment (=) for equality (==)]

B. Infinitely prints the number 2 [Assumed incorrect precedence of operators]

C. Infinitely prints the number 1

D. Prints the following numbers to output: 2 4 6 8

Operator Precedence

Paranthesis () does not mean “Do what is inside the parenthesis first” It specifies how to explicitly bind operators to operands

```
w = x*(y+z)+y*z;

w =(x = 2) && (x < 10);
```

Operator precedence: Default binding of operators to operands in the absence of parenthesis

```
w = (x * y) + z + (y * z);
x = a + (b * c);
x = a || (b && c);
x = (a++) + 10;
x = 2 && (x < 10);
```

Operator Precedence

```
int w, x(0); //same as int w, x=0;

w = (x = (2 && x) < 10));
```

w = (x = ((2 && x) < 10)); // '<' has higher precedence than '='

(Look at table on the next page)

w = (x = ((2 && 0) < 10);

false → 0

w = (x = (0 < 10));

w = (x = true);

w = (x = 1); //true is value '1'

w = 1 ; // x gets the value 1
// w gets the value 1

Operator Precedence

```
int w, x(0); //same as int w, x=0;

w = (x = 2 && x < 10);
```

w = (x = 2 && (x<10));

// '<' has higher precedence than '='

w = (x= (2 && (x<10)));

// '&&' has higher precedence than '='

w = (x = (2 && (0<10));

w = (x = (2 && true));

w = (x = true);

w = (x = 1); // x is assigned!

w = 1 ; // w is assigned!

Precedence	Operator	Description	Associativity
1	::	Scope resolution	Left-to-right
2	a++ a--	Suffix/postfix increment and decrement	
	type() *type*{}	Functional cast	
	a()	Function call	
	a[]	Subscript	
	. ->	Member access	
3	++a --a	Prefix increment and decrement	Right-to-left
	+a -a	Unary plus and minus	
	! ~	Logical NOT and bitwise NOT	
	(*type*)	C-style cast	
	*a	Indirection (dereference)	
	&a	Address-of	
	sizeof	Size-of[note 1]	
	new new[]	Dynamic memory allocation	
	delete delete[]	Dynamic memory deallocation	
4	.* ->*	Pointer-to-member	Left-to-right
5	a*b a/b a%b	Multiplication, division, and remainder	
6	a+b a-b	Addition and subtraction	
7	<< >>	Bitwise left shift and right shift	
8	< <=	For relational operators < and ≤ respectively	
	> >=	For relational operators > and ≥ respectively	
9	== !=	For relational operators = and ≠ respectively	
10	a&b	Bitwise AND	
11	^	Bitwise XOR (exclusive or)	
12	|	Bitwise OR (inclusive or)	
13	&&	Logical AND	
14	||	Logical OR	
15	a?b:c	Ternary conditional[note 2]	Right-to-left
	throw	throw operator	
	=	Direct assignment (provided by default for C++ classes)	
	+= -=	Compound assignment by sum and difference	
	*= /= %=	Compound assignment by product, quotient, and remainder	
	<<= >>=	Compound assignment by bitwise left shift and right shift	
	&= ^= |=	Compound assignment by bitwise AND, XOR, and OR	
16	,	Comma	Left-to-right

Operator Associativity

Operator associativity: Deals with operators that are at the same precedence level or group

- Some groups associate from **left to right** e.g. Arithmetic

  x= a + b – c + d;

  ⇒ x = (((a+b) – c) + d);

  Associate left to right

  Compiler reads

- Other groups associate from **right to left** e.g. Assignment

  x= y = z = 50;

  ⇒ x = (y = (z = 50));

  Associate right to left

  Compiler reads

If x= 100 = z=50; // Results in compiler error, cannot assign a constant to another constant

Order of evaluation

Undefined behavior means outcome can be one of several possibilities

- Deals with which side of an operator is evaluated first (Lt operand or Rt operand). Java/Python strictly defines Lt->Rt. C/C++ do not define order of evaluation

undefined behavior

Evaluate left to right

Evaluate right to left

①
```
b=3;
b = b +(b=9);
```
b = (3 + 9)

b = (9 + 9)

②
```
a =5;
x= a + a++;
```
x = 5 + 5

5 + 5

6 + 5

5 * 5

③
```
int i =4;
cout<< i++ * ++i;
```
4 * 6

or 4 * 5

Review homework 4, problem 3

What is the output of the following program?

```
int x = 0;
while ( x = 2 && x < 10){
    cout << x << endl;
    x+=2;
}
```

apply precedence rules

x = (2 && (0 < 10))

x = (true && true)

x = true

x = 1 ⟹ evaluates to 1 (which is true)

Also x is assigned the value '1'

A. Nothing is printed to output

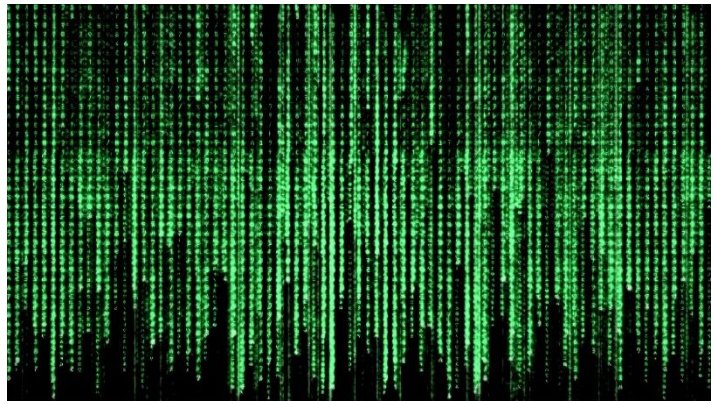
B. Infinitely prints the number 2

C. Infinitely prints the number 1

D. Prints the following numbers to output: 2 4 6 8

What does ‘data’ on a computer look like?

- Imagine diving deep into a computer
- Expect to see all your data as high and low voltages
- In CS we use the abstraction:
  - High voltage: 1 (true)
  - Low voltage: 0 (false)



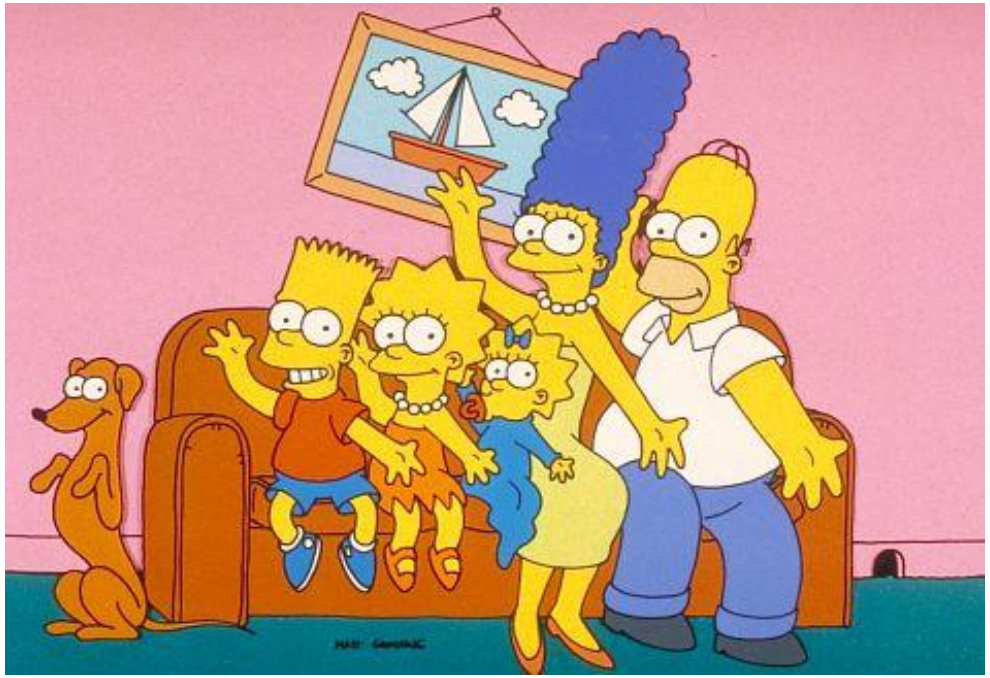
Decimal (base ten)

Symbols: 0 - 9

- Why do we count in base ten?
- Which base would the Simpson's use?

Octal

Symbols: 0-7



Positional encoding for non-negative numbers

- Each position represents some power of the base

Base	Digits	Example
Decimal (10)	0-9	$\underline{5}\ \underline{7}\ \underline{8} = 5*100+7*10+8*1$ $100\ \ 10\ \ 1$
Hex (16)	0-9 A (10), B (11), C (12), D (13), E (14),	$\underline{0}\ \underline{1}\ \underline{0} = 16*1 = 16_{10}$ $256\ \ 16\ \ 16^0$

$\underline{A}\ \underline{1} = 10*16+1 = 161$
$16\ \ 1$

Why is each base important??

Binary representation (base 2)

- On a computer all data is stored in binary
- Only two symbols: 0 and 1
- Each position is called a *bit*
- *For example:*

0 1 0 1

8 4 2 1

= 5 (in decimal)

In code specify base as:

y = 0b101

This means "using base 2"

y = 0x101

This means "using base 16"

101_5 = ? In decimal

A. 26

B. 51

C. 126

D. 130

In base 5

1 0 1

25 5 1

$= 25*1 + 0*5 + 1*1$

$= 26$

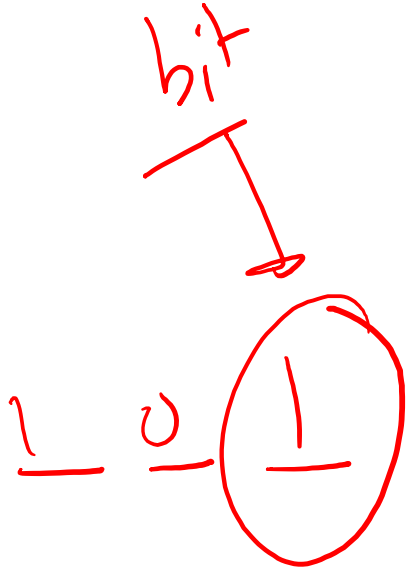
You applied a generalized polynomial expansion to evaluate the answer!

External vs. Internal Representation

- External representation:
  - Convenient for programmer

decimal, hex

(Binary)



- Internal representation:
  - Actual representation of data in the computer's memory and registers: Always binary (1's and 0's)

Bits take up space!

Questions for next class →

8 bits makes a byte

Why is **char** one byte?

Why is **int** 4 bytes?

Next time

- Conversion between different bases
- Representing other types of data