15-122: Principles of Imperative Computation — Spring 2023

Recitation 12: C-ing is Believing — Thursday April 6th

`printf`

Like C0, C provides `printf` to print values to terminal. However, C supports many more format specifiers than C0 (which has only `%d`, `%s` and `%c`). Particularly useful are

- `%u` to print an **`unsigned int`**,
- `%ld` to print a **`long`**,
- `%lu` to print an **`unsigned long`**, and
- `%zu` to print a `size_t`, and

Feel free to search online for format specifiers for more types.[1]

An argument corresponding to `%d` (or `%i`) **must** have type **`int`** (or smaller signed types like **`short`** and **`signed char`**). Providing an argument of any other type is undefined behavior — it may print the expected result, or it may not on any given execution. Thus,

```c
int z = -500;
printf("%u\n", z);
```

is undefined behavior.

`structs` on the stack

In C0 and C1, if we ever wanted to create a **`struct`**, we had to explicitly allocate memory for it using **`alloc`**. C doesn't have this restriction — you can declare **`struct`** variables on the stack, just like **`int`**'s. We set a field of a **`struct`** with dot-notation, below. Recall that when we had a *pointer* `p` to a **`struct`**, we accessed its fields with `p->data`. This is just syntactic sugar for `(*p).data`.

Checkpoint 0

```c
#include <stdio.h>

struct point {
  int x;
  char y;
};

int main () {
  struct point a;
  a.x = 3;
  a.y = 'c';
  struct point b = a;
  b.x = 4;
  printf("a.x, a.y: %d, %c\n", a.x, a.y); // what gets printed out here?
  printf("b.x, b.y: %d, %c\n", b.x, b.y); // how about here?
}
```

[1] The C++ document `http://cplusplus.com/reference/cstdio/printf` is a good reference (C behaves similarly).

Addressing all things

We have already seen the "address-of" operator, &, used to find function pointers in C1. In C, we can do the same thing with variables. This is useful if you want to give a function a reference to a local variable. *Remember to only free pointers returned from* `malloc`*!*

Checkpoint 1

```
#include <stdio.h>
#include "lib/contracts.h"

void bad_mult_by_2(int x) {
  x = x * 2;
}

void mult_by_2(int* x) {
  REQUIRES(x != NULL);
  *x = *x * 2;
}

int main () {
   int a = 4;
   int b = 4;
   bad_mult_by_2(a);
   mult_by_2(&b);
   printf("a: %d   b: %d\n", a, b);
   return 0;
}
```

```
#include <stdio.h>
#include "lib/contracts.h"
struct point {
  int x;
  int y;
};
void swap_points(struct point* P) {
  REQUIRES(P != NULL);
  int temp = P->x;
  P->x = P->y;
  P->y = temp;
}
int main() {
  struct point A;
  A.x = 122;
  A.y = 15;
  swap_points(&A);
  printf("A: (%d, %d)\n", A.x, A.y);
  return 0;
}
```

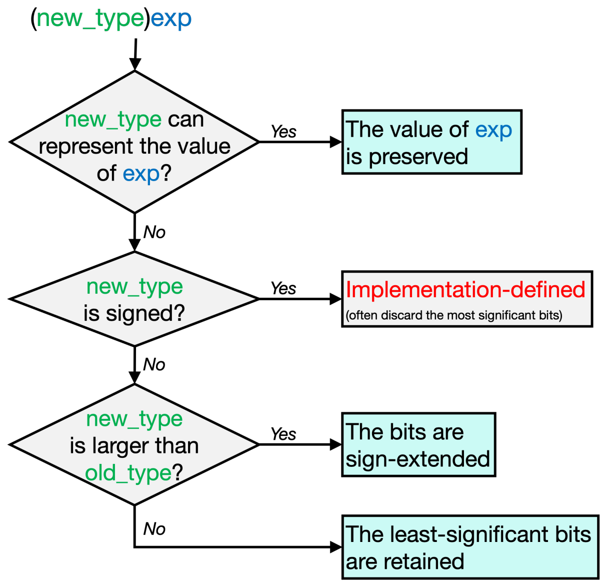
What is the output when each of these programs are run?

Casting

C provides many different types to represent integer values. Some are signed while other are unsigned, and they don't necessarily are 32-bit long (for example a **`short`** is commonly 16 bits).

Sometimes, if we really know what we are doing, we may want or need to convert between these types. We can do so by *casting*. The flow chart to the right summarizes what happens when casting a numerical expression `exp` of type `old_type` to type `new_type`.

The general rule of thumb is that value is preserved whenever possible, and the bit pattern is preserved otherwise.



Here is one example of each situation:

```
// -3 is representable as an int
signed char x = -3;              // x is -3 (= 0xFD)
int y = (int)x;                  // y is -3 (= 0xFFFFFFFD)

// -241 is NOT representable as a SIGNED char and the new type is signed
int x = -241;                    // x is -241(= 0xFFFFFF0F)
signed char y = (signed char)x;  // y is ?? (often 0x0F)

// -3 is NOT representable as a UNSIGNED int, the new type is bigger
signed char x = -3;              // x is -3 (= 0xFD)
unsigned int y = (unsigned int)x;    // y is 4294967293 (= 0xFFFFFFFD)

// -3 is NOT representable as a UNSIGNED char, the new type and smaller or equal
signed char x = -3;              // x is -3  (= 0xFD)
unsigned char y = (unsigned char)x;  // y is 253 (= 0xFD)
```

Most casts between pointers and integers are implementation-defined.

`switch` statements

A **`switch`** statement is a different way of expressing a conditional. Here's an example:

```
void print_dir(char c) {
  switch (c) {
    case 'l':
      printf("Left\n");
      break;
    case 'r':
      printf("Right\n");
      break;
    case 'u':
      printf("Up\n");
      break;
    case 'd':
      printf("Down\n");
      break;
    default:
      fprintf(stderr, "Specify a valid direction!\n");
  }
}
```

Each case's value should evaluate to a constant integer type (this can be of any size, so **`char`**s, **`int`**s, **`long long int`**s, etc).

The **`break`** statements here are important: If we don't have them, we get fall-through: without the break on line 11 we'd print "Up" and then "Down" for case `'u'`.

Checkpoint 2

Fall-through is useful but can be tricky. What's wrong with the following code? How do you fix it?

```
#include <stdio.h>
#include <stdlib.h>
void check_parity(int x) {
  switch (x % 2) {
    case 0:
      printf("x is even!\n");
    default:
      printf("x is odd!\n");
  }
}
```

Checkpoint 3

What's wrong with each of these pieces of code?

(a)
```c
int* add_sorta_maybe(int a, int b) {
  int x = a + b;
  return &x;
}
```

(b)
```c
void print_int(int* i) {
  printf("%d\n", *i);
  free(i);
}

int main() {
  int x = 6;
  print_int(&x);
  return 0;
}
```

(c)
```c
int main() {
  int x = 0;
  if (x = 1)
    printf("woo\n");
  return x;
}
```

(d)
```c
int main () {
  unsigned int x = 0xFE1D;
  short y = (short)x;
  return 0;
}
```

(e)
```c
int main() {
  char* s = "15-122";
  s[4] = '1'; // blasphemy
  printf(s);
  return 0;
}
```

(f)
```c
int main() {
  char s[] = {'a', 'b', 'c'};
  printf("%s\n", s);
  return 0;
}
```