Computer Programming: Skills & Concepts (CP1)
Redoing coin change; Booleans; Expressions and Precedence

11th November, 2010

Coin Change

Remember the task:
We want to write a program that

- ask the user for an amount of money
- calculates the coins needed for this amount
- outputs the number of each coin

Recall that solution was very ugly – different constants for each coin type, multi-branch conditionals, and so on. Moreover, the coin values were hard-wired – suppose we wanted US coins!
This was because we didn't know about arrays.
So here is Coin Change done as we would now do it:

Type of Coins

Coins range from 1p to £2

```
/* array of coin values in decreasing order */
const int coinValues[] = { 200, 100, 50, 20, 10, 5, 2, 1 };

/* number of different types of coin -
   using a sneaky way to avoid counting them */
const int NUM_VALUES = sizeof(coinValues)/sizeof(int);

/* names for the coins */
const char *coinNames[]= { "two pound", "one pound",
              "50p", "20p", "10p", "5p", "2p", "1p" };
```

Function structure of Program

type definitions as just given

the `ReadInput` *function as before*

```
int CalculateCoins(int amount, int len,
                   const int cValues[],
                   int cNums[] ) {
    calculate numbers of coins, store in cNums
}

int PrintAmount(int amount, int len,
                const int cNames[],
                const int cNums[]) {
    print out the amount
}
```

Missing out the error handling (do it as before):

```
int main(void) {
  int amount;
  int coinNums[NUM_VALUES];

  ReadInput(&amount);
  CalculateCoins(amount, NUM_VALUES, coinValues,
                 coinNums);
  PrintAmount(amount, NUM_VALUES, coinNames,
              coinNums);

  return EXIT_SUCCESS;
}
```

Calculate Coins

```
int CalculateCoins(int amount, int len,
                   const int cValues[],
                   int cNums[] ) {
  int pot = amount;  // Amount left to deal with
  int i = 0;
  while ( pot > 0 && i < len ) {
    int n = pot / cValues[i];
    pot -= n * cValues[i];
    cNums[i] = n;
    i++;
  }
  return EXIT_SUCCESS;
}
```

Output to User

```
int PrintAmount(int amount, int len,
                const char *cNames[],
                const int cNums[]) {
  printf("%dp may be returned using the following "
         "combination of coins:\n", amount);
  int i;
  for (i=0; i<len; i++) {
    if (cNums[i] > 0) {
      printf("%d %s coins\n", cNums[i], cNames[i]);
    }
  }
  return EXIT_SUCCESS;
}
```

Exercises

(1) It's rather ugly that we have separate arrays for coin values and names – suppose we get them out of sync!
Define a type `struct coin { int value; char *name; }` and re-write the program that way.

(2) Handle the punctation between lines of output, and the use of plurals ('coin'/'coins') correctly. (This is tedious!)

Booleans

`&&` ("and"):

- *usage* is `d && s`, for `d,s` booleans.
- *meaning* is like 'and' in English, eg, "it is dry and it is sunny".

`||` ("or"):

- *usage* is `t || s`, for `t,s` booleans.
- *meaning* is like 'or' in English, eg "Tesco or Scotmid will be open".
- NOT *exclusive* or: `t || s` also holds if *both* `t` and `s` hold.

`!` ("not"):

- `!p` is true if and only `p` is false.

Examples

```
char c='F';
const int false=0; true=1;


(1 < 9) || (2 == 5)
IsSunny(today) || true
('A' <= c) && (c <= 'Z')
false && (1 == 1)
```

Boolean as int

- Booleans are represented as integers in C.
- 1 is the value of a true expression:
  `(x == x)` is `1`
- 0 is the value of a false expression:
  `x < x` is `0`
- Non-zero values are treated as true:

```
while(45){ };
/* loop forever */
```

Truth Table

`expr1`	`expr2`	`!expr1`	`expr1 && expr2`	`expr1 || expr2`
false	false	true	false	false
false	true	true	false	true
true	false	false	false	true
true	true	false	true	true

Truth Table (as `int`)

`expr1`	`expr2`	`!expr1`	`expr1 && expr2`	`expr1 || expr2`
0	0	1	0	0
0	non-zero	1	0	1
non-zero	0	0	0	1
non-zero	non-zero	0	1	1

"short-circuit" to testing

`&&` and `||` expressions are evaluated in order:

- eg, `first && second`
- Arithmetic expressions DO NOT have this property

For Boolean expressions, *evaluation* ends as soon as the outcome is known:

- eg `false && never`
- eg `(x == x) || never`

Testing elements of an array

```
int CheckRange(int max, int *array, int length) {
  int i = 0;
  while (i < length) {
    if (array[i] > max)
      break;
    i++;
  }
  if (i < length)      /* We broke out of the loop early */
    return 0;
  else return 1;
}
```

Testing elements ... "short-circuit" version

```
int CheckRange2(int max, int *array, int length) {
  int i = 0;
  while ((i < length) && (array[i] <= max)) {
    i++;
  }
  if (i < length)     /* We broke out of the loop early */
    return 0;
  else return 1;
}
```

Watch out!

Don't assume that *arithmetic* expressions will evaluate in order. For example:

```
x = 10;
y = ++x + x;
```

In practice, depending on compiler, this could evaluate as either of the following:

```
y = 11 + 11;                    /* ++x; y = x + x; */
y = 11 + 10;                    /* y = x; ++x; y += x; */
```

Avoid writing code with these ambiguous interpretations.

Precedence – highest to lowest

()	[]	++	--	
*	/	%		
+	-			
<	<=	>	>=	
==	!=			
&&				
||				
=	+=	-=	*=	/= etc

Left to right ordering within same precedence level.

Precedence determines *bracketing* of expression.

Precedence **does not** determine order of evaluation.

Watch out . . .

The common mathematical short-hand `3 < j < 6`
. . . is evaluated as `(3 < j) < 6`
Suppose `j` is 7. Then the sequence of evaluations is:

```
(3 < 7) < 5
= 1 < 5    /* 1 is the result (true) of 3 < 7 */
= 1        /* representing true */
```

Must be clear and write `(3 < j) && (j < 6)`