Review of Scientific Programming in C and Fortran

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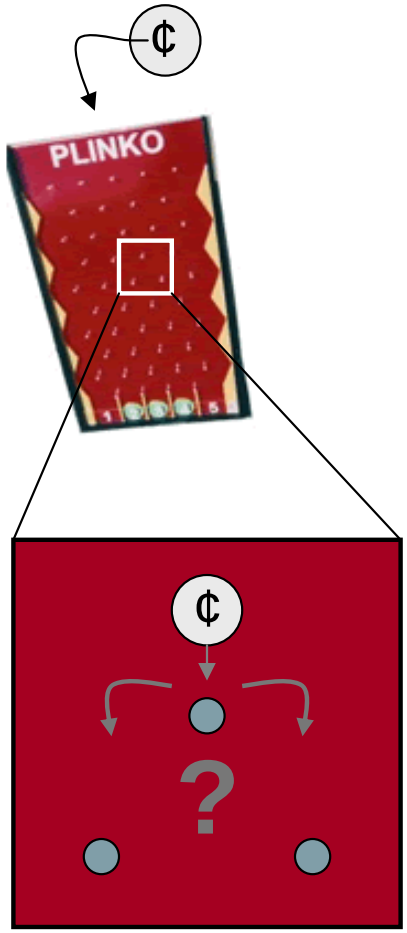
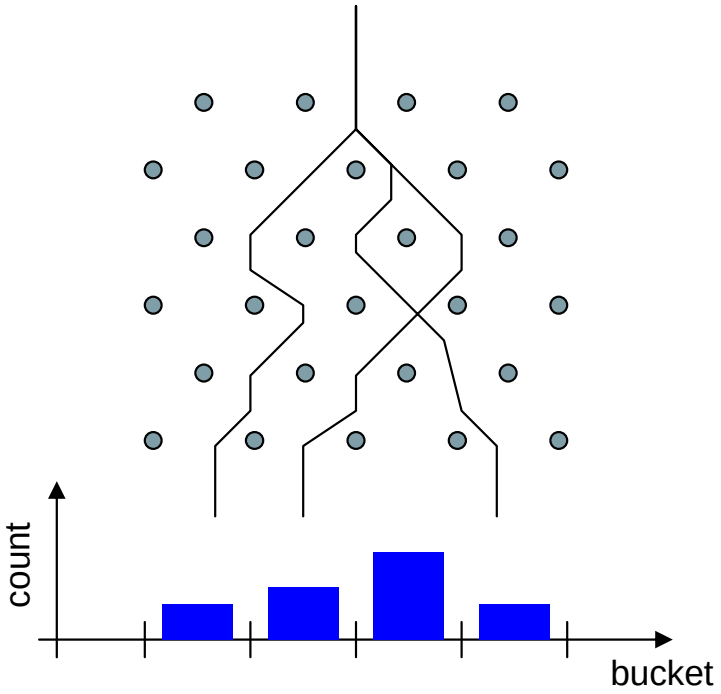
Monte Carlo Simulator



50/50 chance left or right at each peg

Simulate by randomly generating thousands of tracks



Plinko Simulator in C

```
#include <stdio.h>
#include <stdlib.h>
#include <math.h>

#define LEVELS 9

int
main(int argc, char **argv)
{
    int max, drop, i, pos, count[LEVELS+1];
    double rnum;

    printf("number of drops?\n");
    if (scanf("%d", &max) != 1) {
        fprintf(stderr,"bad number!\n");
        exit(1);
    }

    for (i=0; i < LEVELS+1; i++) {
        count[i] = 0;
    }
```

Definitions of functions we'll use below

Constant value, substituted wherever it is referenced in the rest of the file

Plinko Simulator in C

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main(int argc, char **argv)
{
    int max, drop, i, pos, count[LEVELS+1];
    double rnum;

    printf("number of drops?\n");
    if (scanf("%d", &max) != 1) {
        fprintf(stderr,"bad number!\n");
        exit(1);
    }

    for (i=0; i < LEVELS+1; i++) {
        count[i] = 0;
    }
```

Main program must be defined like this

number of drops?
500

"%d" → max

Quit the program and indicate that it failed:
exit(0) → "ok"
exit(1) → "failure"

Plinko Simulator in C

```
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#include <stdlib.h>
#include <math.h>

#define LEVELS 9

int
main(int argc, char **argv)
{
    int max, drop, i, pos, count[LEVELS+1];
    double rnum;

    printf("number of drops?\n");
    if (scanf("%d", &max) != 1) {
        fprintf(stderr,"bad number!\n");
        exit(1);
    }

    for (i=0; i < LEVELS+1; i++) {
        count[i] = 0;
    }
```

Done once before loop

Determines when to quit

Increment `i` at bottom of loop

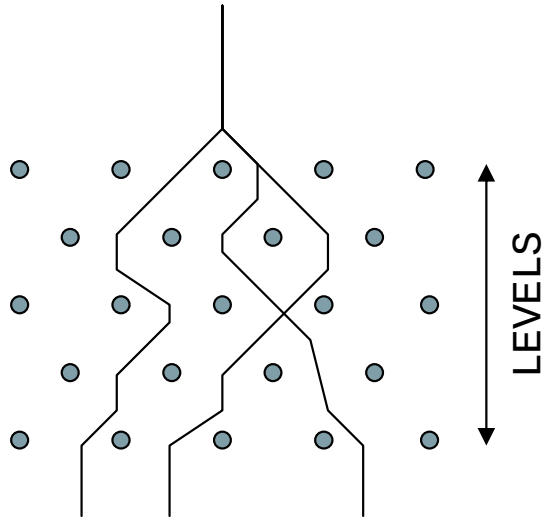
```
count[0] = 0;
count[1] = 0;
count[2] = 0;
...
```

C arrays start at 0

Plinko Simulator in C

```
    …
    for (drop=0; drop < max; drop++) {
        pos = LEVELS;
        for (i=0; i < LEVELS; i++) {
            pos += (drand48() < 0.5) ? -1 : 1;
        }
        count[pos/2]++;
    }

    /* print out final results */
    printf("Statistics:\n");
    for (i=0; i < LEVELS+1; i++) {
        printf("Bucket %d: %d\n", i, count[i]);
    }
    return 0;
}
```



Check random number

Less than 0.5, go left

Otherwise, go right

Add on to value:

```
pos += 1;
pos = pos + 1;
```

Lather, rinse, repeat…

Plinko Simulator in C

```
    …
    for (drop=0; drop < max; drop++) {
        pos = LEVELS;
        for (i=0; i < LEVELS; i++) {
            pos += (drand48() < 0.5) ? -1 : 1;
        }
        count[pos/2]++;
    }

    /* print out final results */
    printf("Statistics:\n");
    for (i=0; i < LEVELS+1; i++) {
        printf("Bucket %d: %d\n", i, count[i]);
    }
    return 0;
}
```

Comment text

Statistics:
Bucket 0: 2
Bucket 1: 7
Bucket 2: 23
…

"Bucket %d: %d"

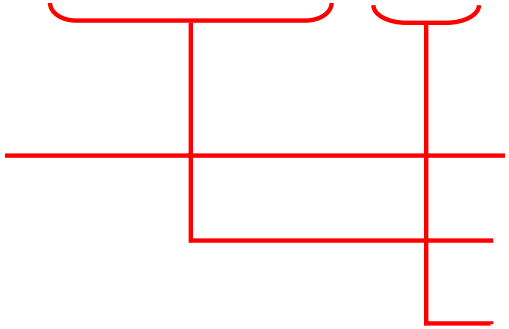
i count[i]

Same as `exit(0)`
Everything is "ok"

Compiling and Running C Code

```
$ gcc -g plinko.c -o plinko -lm

$ ./plinko
number of drops?
500
Statistics:
Bucket 0: 1
Bucket 1: 14
Bucket 2: 24
Bucket 3: 87
Bucket 4: 137
Bucket 5: 102
Bucket 6: 95
Bucket 7: 29
Bucket 8: 10
Bucket 9: 1
```



- Add debugging info for later
- Create executable called “plinko”
- Include math library for drand48()

C Language Cheat Sheet

Conditionals:

```
if (x > 0) {
    statements;
}

if (x > 0) {
    statements;
} else if (x < 0) {
    statements;
} else {
    statements;
}

switch (x) {
    case 1:
        statements;
        break;
    case 2:
    default:
        statements;
}
```

Looping:

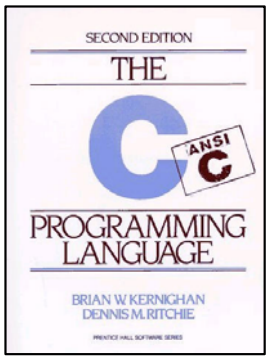
```
while (x != 0) {
    statements;
}

do {
    statements;
} while (x < 10);

for (x=0; x < 10; x++) {
    statements;
}
```

break ← *Break out of loop*

continue ← *Go back to top of loop*



Plinko Simulator in Fortran

```
      program plinko

      implicit none
      integer levels
      parameter ( levels=9 )

      integer max, drop, i, pos,
     +        count(levels+1)
      double precision rnum;

      write(6,*) 'Number of drops?'
      read(5,*) max

c     set all counts to zero
      do 10 i=1,levels+1
        count(i) = 0;
10    continue
```

6 spaces, start in col 7

Continue on the next line by putting + in column 6

Character in this spot makes the line a comment

Line numbers start in column 2

lines limited to 80 characters →

Plinko Simulator in Fortran

```
      program plinko

      implicit none
      integer levels
      parameter ( levels=9 )

      integer max, drop, i, pos,
     +        count(levels+1)
      double precision rnum

      write(6,*) 'Number of drops?'
      read(5,*) max

c     set all counts to zero
      do 10 i=1,levels+1
        count(i) = 0
10    continue
```

Fortran assumes…
i-n → integer
a-h o-z → real
This turns that off

Defines a constant

```
count(1) = 0
count(2) = 0
count(3) = 0
…
```

Fortran arrays start at 1

Plinko Simulator in Fortran

```
      do 20 drop=1,max
        pos = levels
        do 30 i=1,levels
          if (rand().lt.0.5) then
            pos = pos - 1
          else
            pos = pos + 1
          endif
 30     continue
        count(pos/2+1) = count(pos/2+1) + 1
 20   continue

c     write out final results
      write(6,*) 'Statistics:'
      do 40 i=1,levels+1
        write(6,99) i, count(i)
 40   continue
 99   format('Bucket ',i5,': ',i5)

      end
```

Conditional operators:

`.lt.`	less than
`.le.`	less than or equal to
`.gt.`	greater than
`.ge.`	greater than or equal to
`.eq.`	equal to
`.ne.`	not equal to
`.and.`	logical and
`.or.`	logical or

Don’t care about the format

Fortran Cheat Sheet

Conditionals:

```
if (x .gt. 0) then
    statements
endif

if (x .gt. 0) then
    statements
elseif (x .lt. 0) then
    statements
else
    statements
endif
```

Looping:

"while loop"

```
10  if (x .lt. 10) then
      statements;
      goto 10
    endif
```

"do-while loop"

```
20  continue
      statements;
    if (x .lt. 10) goto 20
```

"for loop"

```
    do 30 x=1,10,2
      statements;
30  continue
```

Compiling and Running Fortran Code

```
$ g77 -g plinko.f -o plinko

$ ./plinko
 Number of drops?
500
 Statistics:
Bucket      1:      1
Bucket      2:      9
Bucket      3:     28
Bucket      4:     77
Bucket      5:    141
Bucket      6:    124
Bucket      7:     75
Bucket      8:     35
Bucket      9:      8
Bucket     10:      2
```

Add debugging info for later

Create executable called “plinko”

Makefiles

```
$ gcc -g plinko.c -o plinko -lm
$ vi plinko.c
$ gcc -g plinko.c -o plinko -lm
$ vi plinko.c
…

$ make
$ vi plinko.c
$ make all
$ vi plinko.c
$ make
$ make
```

No changes, does nothing

Follows the instructions in a “make” file

file: `Makefile`

```
plinko: plinko.c
    gcc -g plinko.c -o plinko -lm

clean:
    rm -f *.o plinko
```

(TAB before each command)

```
$ make clean
```

Clean up and start from scratch

Debugging

What if something goes horribly wrong?

```
$ ./plinko
 Number of drops?
500
Segmentation Fault (Core Dumped)
```

```
$ gdb plinko
(gdb) l
4
5       #define LEVELS 9
6
7       int
8       main(int argc, char **argv)
9       {
10          int max, drop, i, pos, count[LEVELS+1];
11          double rnum;
12
13          printf("number of drops?\n");
(gdb) break 13
Breakpoint 1 at 0x80484c5: file plinko.c, line 13.
```

Start GNU debugger with your program (must be compiled -g)

Stop at this line

Debugging

```
(gdb) break 13
Breakpoint 1 at 0x80484c5: file plinko.c, line 13.
(gdb) run
Starting program: /home/nanohub/mmc/bootcamp2008/plinko/c/plinko

Breakpoint 1, main () at plinko.c:13
13          printf("number of drops?\n");
(gdb) n
number of drops?
14          if (scanf("%d", &max) != 1) {
(gdb) n
500
19          for (i=0; i < LEVELS+1; i++) {
(gdb) n
20              count[i] = 0;
(gdb) n
19          for (i=0; i < LEVELS+1; i++) {
(gdb) p i
$1 = 1
```

Debugging

```
(gdb) break 24 if drop == 3
Breakpoint 2 at 0x8048540: file plinko.c, line 24.
(gdb) c
Continuing.

Breakpoint 2, main () at plinko.c:24
24                pos = LEVELS;
(gdb) p drop
$2 = 3
```

Cheat Sheet

`l` *line*	… list source code (starting at optional line)
`break` *line*	… stop at this line
`run` *arg arg*	… run program with these arguments
`n`	… next
`s`	… step (step inside routines)
`c`	… continue running to next breakpoint
`p` *expr*	… print out value of expression