CSE 333 – SECTION 2

gdb, valgrind, pointers & structs

Questions, Comments, Concerns

- Do you have any?
- Exercises going ok?
- Lectures make sense?
- Homework 1 – START EARLY!

Upcoming Due Dates:

- Due Friday: Exercise 4 @ 10 am
- Due Monday: Exercise 5 @ 10 am
- Due Wednesday: Exercise 6 @ 10 am
- Due in 1 week: HW1 @ 11:59 pm

Motivation & Tools

- The projects are big, lots of potential for bugs
- **Debugging is a skill that you will need throughout your career**

- gdb (GNU Debugger) is a debugging tool
  - Handles more than just assembly.
  - Lots of helpful features to help with debugging
  - Very useful in tracking undefined behavior

- Valgrind is a memory debugging tool
  - Checks for various memory errors
  - If you are running into odd behavior, running valgrind may point out the cause.

run reverse.c

Segmentation fault

- Causes of segmentation fault
  - Dereferencing uninitialized pointer
  - Null pointer
  - A previously freed pointer
  - Accessing end of an array
  - …
- gdb (GNU Debugger) is very helpful for identifying the source of a segmentation fault
    - backtrace

reverse.c + backtrace

Man pages

- If you are unsure of what a C library function does, use man to find more information.
  - Example: man strcpy

- Note: man also supports various unix commands, but doesn't hold info for C++

Other Esssential gdb Commands

- run <command_line_args>
- backtrace
- frame, up, down
- print <expression>
- quit
- breakpoints
  - (see next slide)

reverse.c demo + code fix

gdb Breakpoints

- Usage:
  - break <function_name>
  - break <filename:line#>
    - Example: break CSE333.c:20
      // ^ sets breakpoint for when Verify333 fails
- Can advance with:
  - continue
  - next
  - step
  - finish
- More info linked from the course website!

reverse.c demo + code fix

Memory Errors

- Use of uninitialized memory
- Reading/writing memory after it has been freed – Dangling pointers
- Reading/writing to the end of malloc'd blocks
- Reading/writing to inappropriate areas on the stack
- Memory leaks where pointers to malloc'd blocks are lost

Valgrind is your friend!!

Pointers and Structs

Defining structs and operators

```
struct course_st {
  char *name;
  uint16_t id;
};

int main(int argc, char **argv) {
  struct course_st a = {"Systems programming", 333};
  struct course_st b;
  struct course_st *bPtr = &b;

  bPtr->name = "Hello world!";
  b.id = 123;

  return EXIT_SUCCESS;
}
```

Typedef

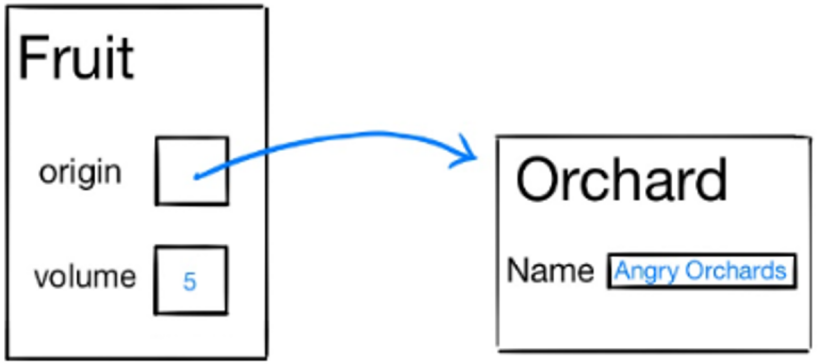
```c
typedef struct course_st {
  char *name;
  uint16_t id;
} Course, *CoursePtr;

int main(int argc, char **argv) {
  Course a = {"Systems programming", 333};
  Course b;
  CoursePtr bPtr = &b;

  bPtr->name = "Hello world!";
  b.id = 123;

  return EXIT_SUCCESS;
}
```

Similar to `int x, *y;`

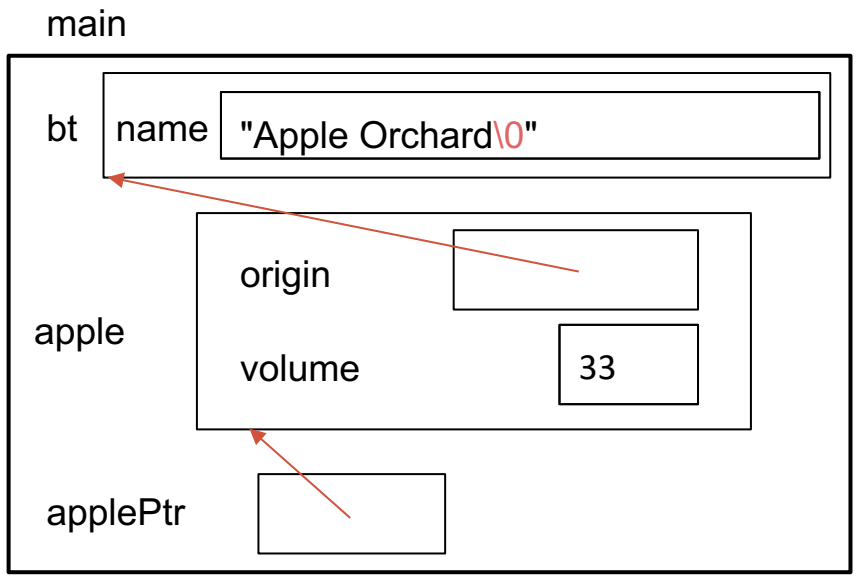
Fruits & Orchards

```
typedef struct fruit_st {
  OrchardPtr origin;
  int volume;
} Fruit;
```

```
typedef struct orchard_st {
  char name[20] ;
} Orchard, *OrchardPtr;
```



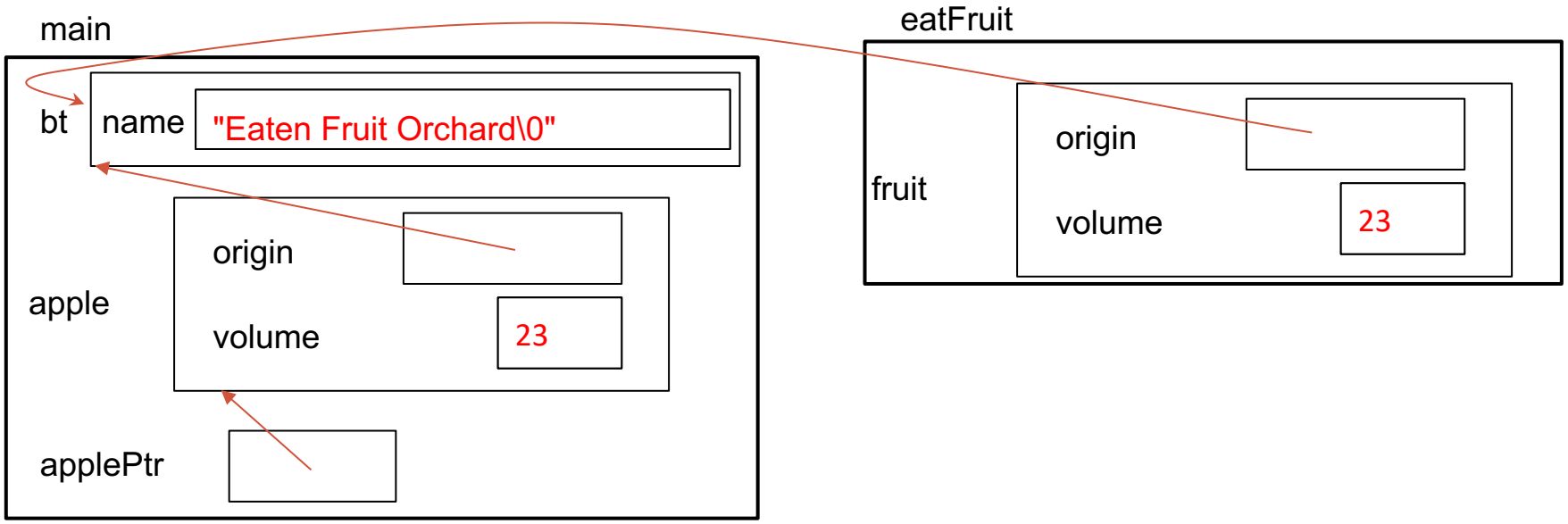
```
int main(int argc, char* argv[]) {
  Orchard bt;
  strcpy(bt.name, "Apple Orchard");

  Fruit apple;
  Fruit* applePtr = &apple;
  apple.origin = &bt;
  apple.volume = 33;
  applePtr->volume = apple.volume;

  printf("1. %d, %s \n",
       applePtr->volume,
       applePtr->origin->name);
  …
```



console output

1, 33, Apple Orchard

```
…
apple.volume = eatFruit(apple);
printf("2. %d, %s \n", applePtr->volume,
                       applePtr->origin->name);
```

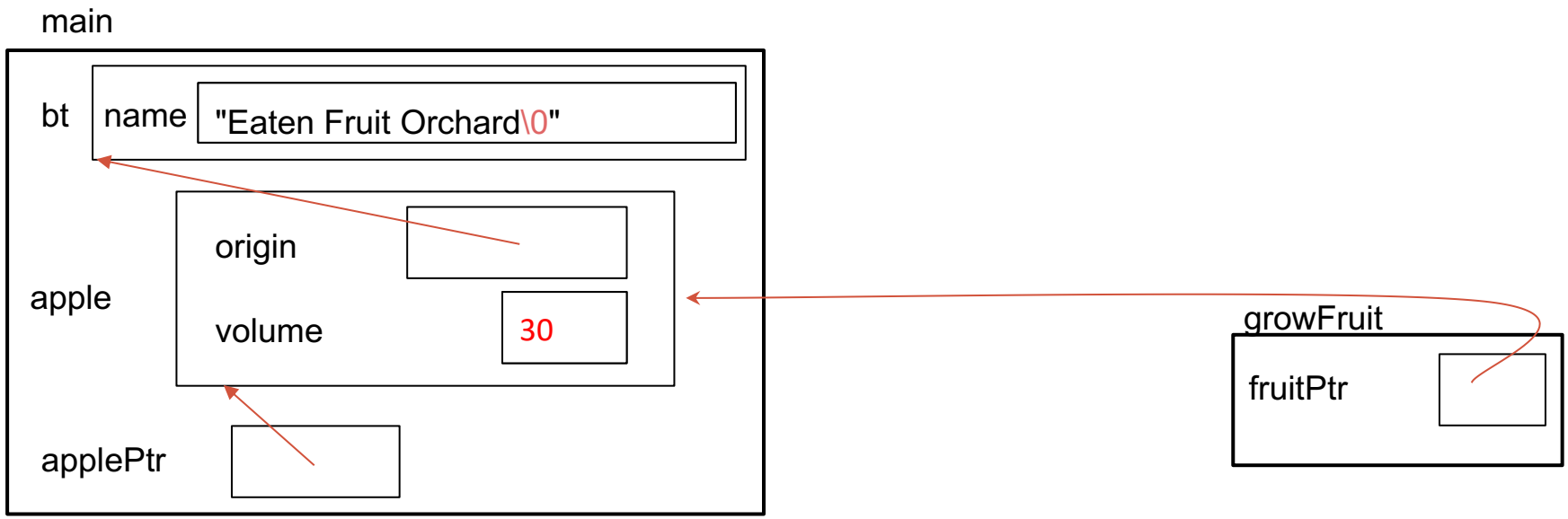



```
int eatFruit(Fruit fruit) {
  fruit.volume -= 10;
  strcpy(fruit.origin->name,
      "Eaten Fruit Orchard");
  return fruit.volume;
}
```

console output

```
1, 33, Apple Orchard
2, 23, Eaten Fruit Orchard
```

```
...
growFruit(applePtr);
printf("3. %d, %s \n", applePtr->volume,
        applePtr->origin->name);
```

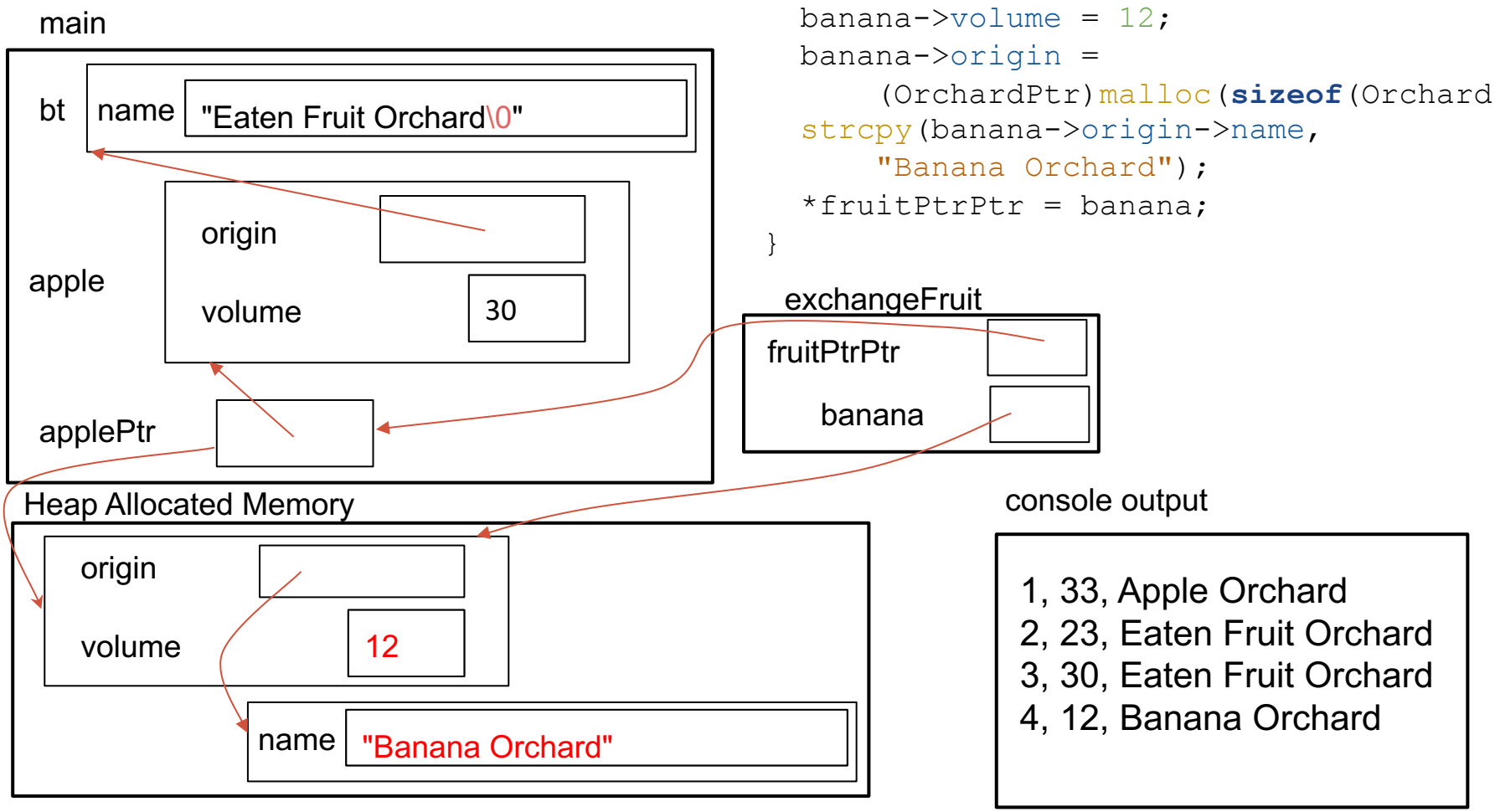



```
void growFruit(Fruit* fruitPtr) {
  fruitPtr->volume += 7;
}
```

console output

```
1, 33, Apple Orchard
2, 23, Eaten Fruit Orchard
3, 30, Eaten Fruit Orchard
```

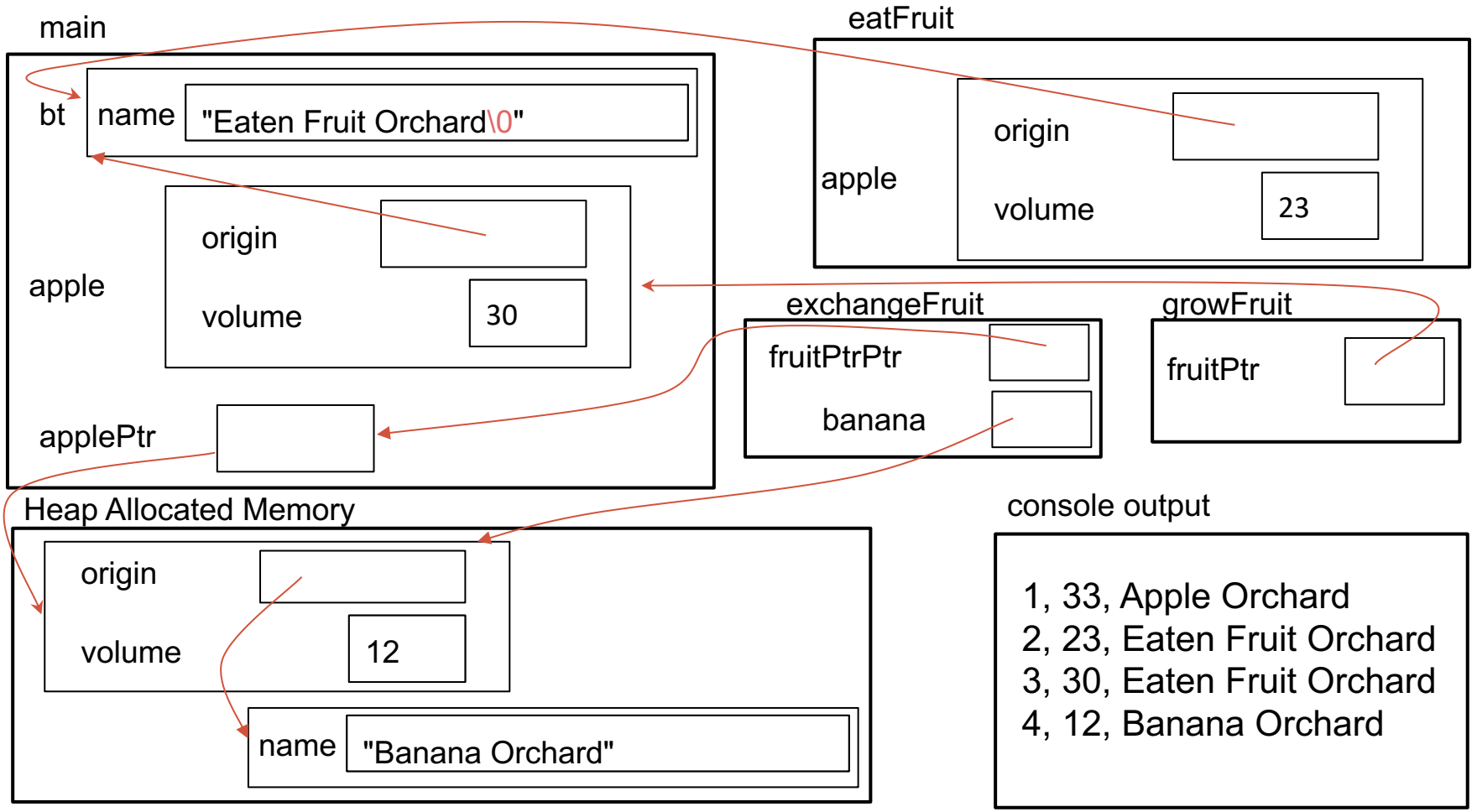
```
void exchangeFruit(Fruit** fruitPtrPtr) {
  Fruit *banana =
       (Fruit*)malloc(sizeof(Fruit));
  banana->volume = 12;
  banana->origin =
       (OrchardPtr)malloc(sizeof(Orchard));
  strcpy(banana->origin->name,
       "Banana Orchard");
  *fruitPtrPtr = banana;
}
```



console output

```
1, 33, Apple Orchard
2, 23, Eaten Fruit Orchard
3, 30, Eaten Fruit Orchard
4, 12, Banana Orchard
```

```
exchangeFruit(&applePtr);
printf("4. %d, %s \n", applePtr->volume,
       applePtr->origin->name);
```


main
bt
name
"Eaten Fruit Orchard\0"
apple
origin
volume
30
applePtr
eatFruit
apple
origin
volume
23
exchangeFruit
fruitPtrPtr
banana
growFruit
fruitPtr
Heap Allocated Memory
origin
volume
12
name
"Banana Orchard"
console output
1, 33, Apple Orchard
2, 23, Eaten Fruit Orchard
3, 30, Eaten Fruit Orchard
4, 12, Banana Orchard

Section exercise

- Handouts.
- Work with a partner, if you wish.
- Look at the expandable vector code in imsobuggy.c.
- First, try to find all the bugs by inspection.
- Then try to use Valgrind on the same code.

Code is located at
https://courses.cs.washington.edu/courses/cse333/20sp/sections/sec2-code/