CS 2113
Software Engineering

From C to Java

Slides from Prof. Tim Wood

Previously...

- We finished up C
  - There is plenty more to learn, but you've had a taste
- You are completing Module 3
  - linked lists and more complex data structures

This Time…

- A bit more C
- More on Linked Lists
- Algorithmic thinking, APIs
- Going from C to Java

Final notes on C

- The benefits of C:
  - Low level coding
  - Direct access to memory
  - Ubiquitous
  - Low overhead
- The dangers of C:
  - Direct access to memory
  - Minimal type checking
  - No support for objects
  - No variable initialization

Final notes on C

- Remember the memory model
  - This is not C specific
  - But other languages hide the details
- Most C bugs are related to how you access memory
  - If in doubt... draw it out!
- How to learn a new language:
  - Small steps!
  - Write code, compile, test, repeat
  - Look at library reference examples

source: Head First C

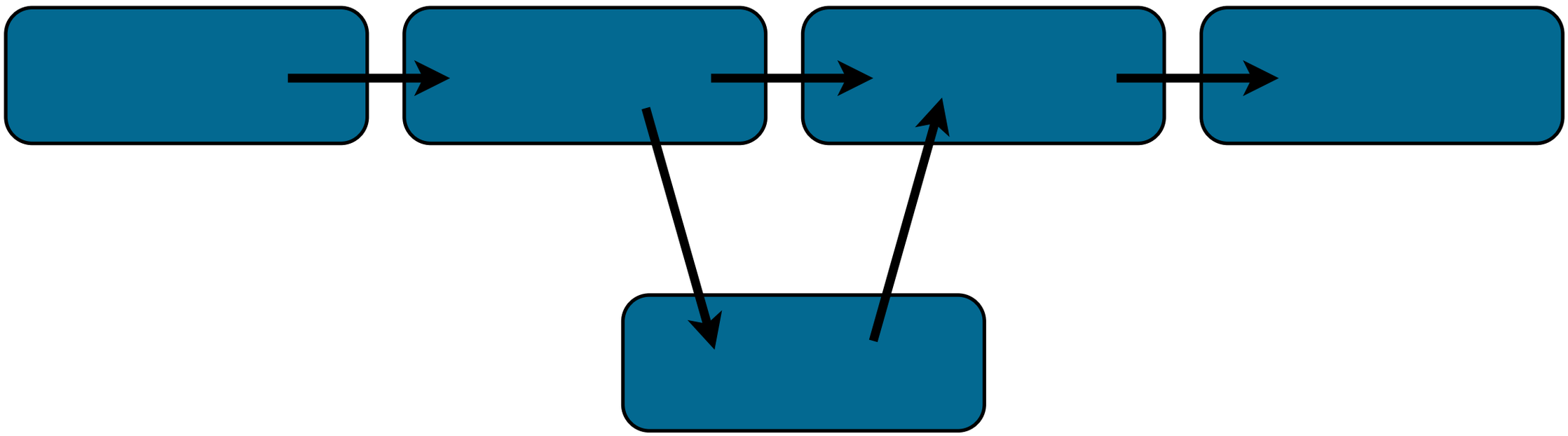
Plan big, code small

- Plan your overall approach
  - Write pseudo code for your algorithm
  - Figure out what data, functions, objects you will need
  - Break the problem into small pieces

- Write code piece by piece
  - Never try to write your whole program at once
  - Write a small piece and test it out
  - Move to the next step when you know one piece works

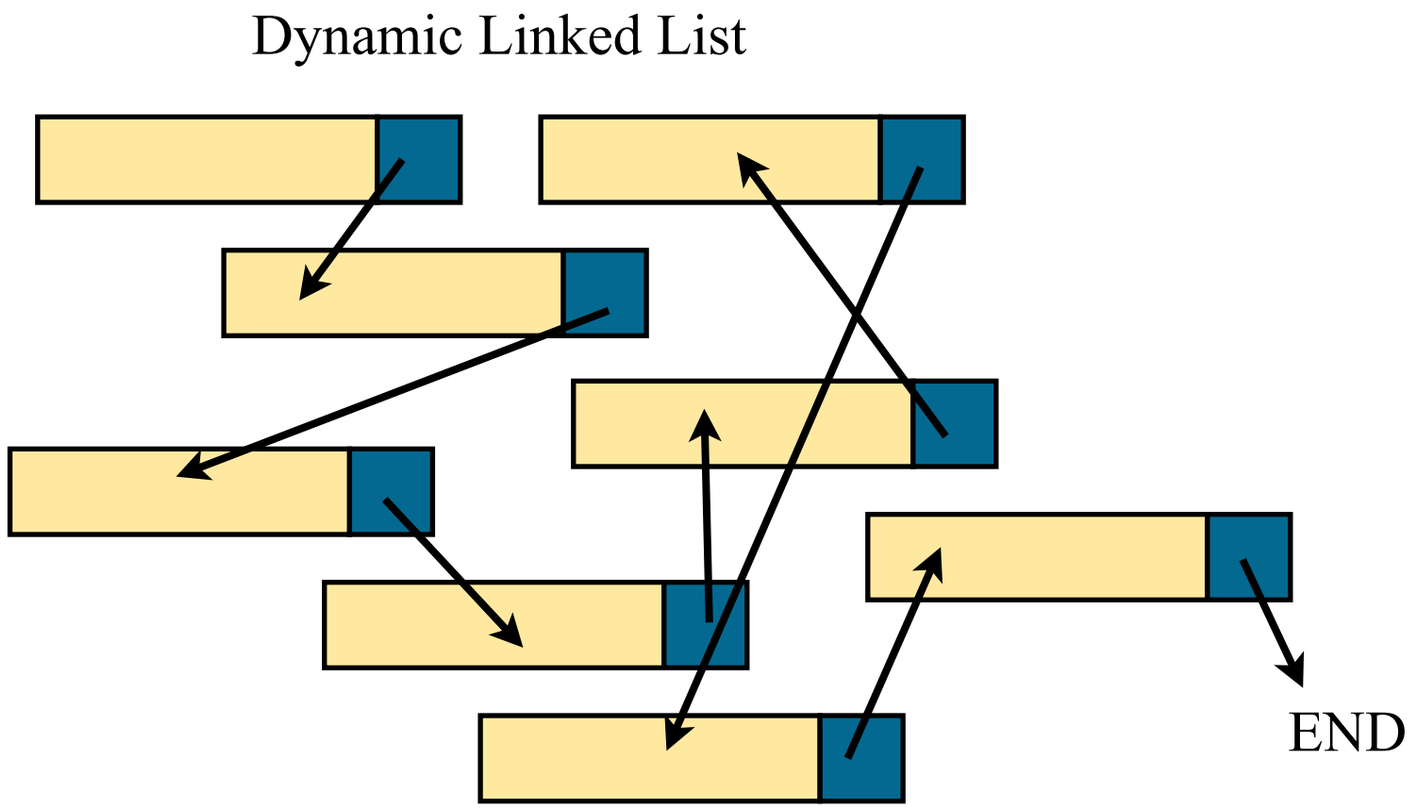
The Linked List

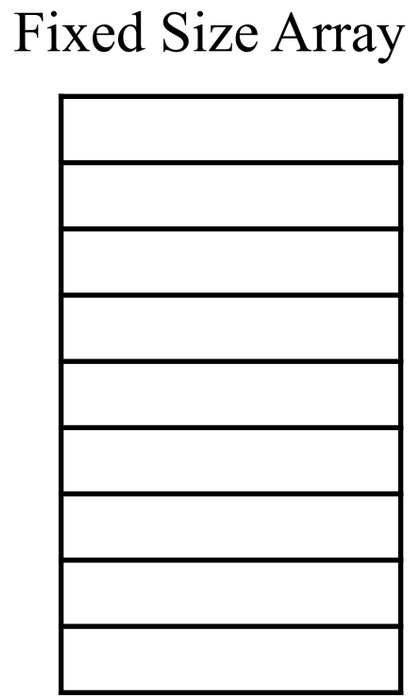
- What is a linked list?
- What can it hold?
- How does it compare to...
  - An array from the stack? **`int days[365];`**
  - or the heap? **`int *days=malloc(365*sizeof(int));`**



The Linked List

- Strength: Very flexible
  - Can grow at both ends or in the middle
  - Fast to add elements anywhere
- Weakness: Slow access time
  - Must traverse through list to find element
  - Memory overhead due to "next" pointers





What functions do we need?

- A linked list should be able to...

What functions do we need?

- A linked list should be able to...

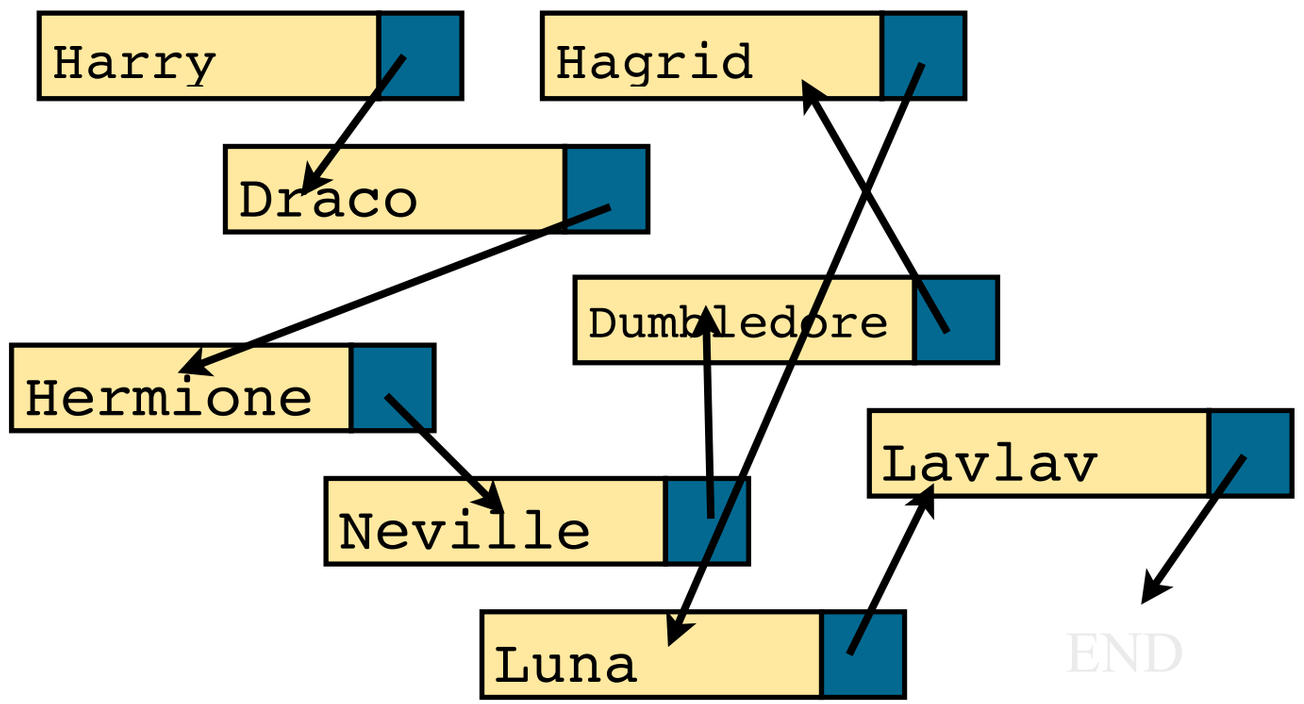
Application Program Interface

- We just did **software engineering**!
  - SE is about a lot more than writing code and knowing syntax
- An API describes an interface
  - What functionality is exposed? What data is available?
- Is our Linked List interface C-specific?

What data do we need?

- How should we represent the list?

- Linked List
  - pointer to first Node
- Node
  - String name
  - pointer to next Node

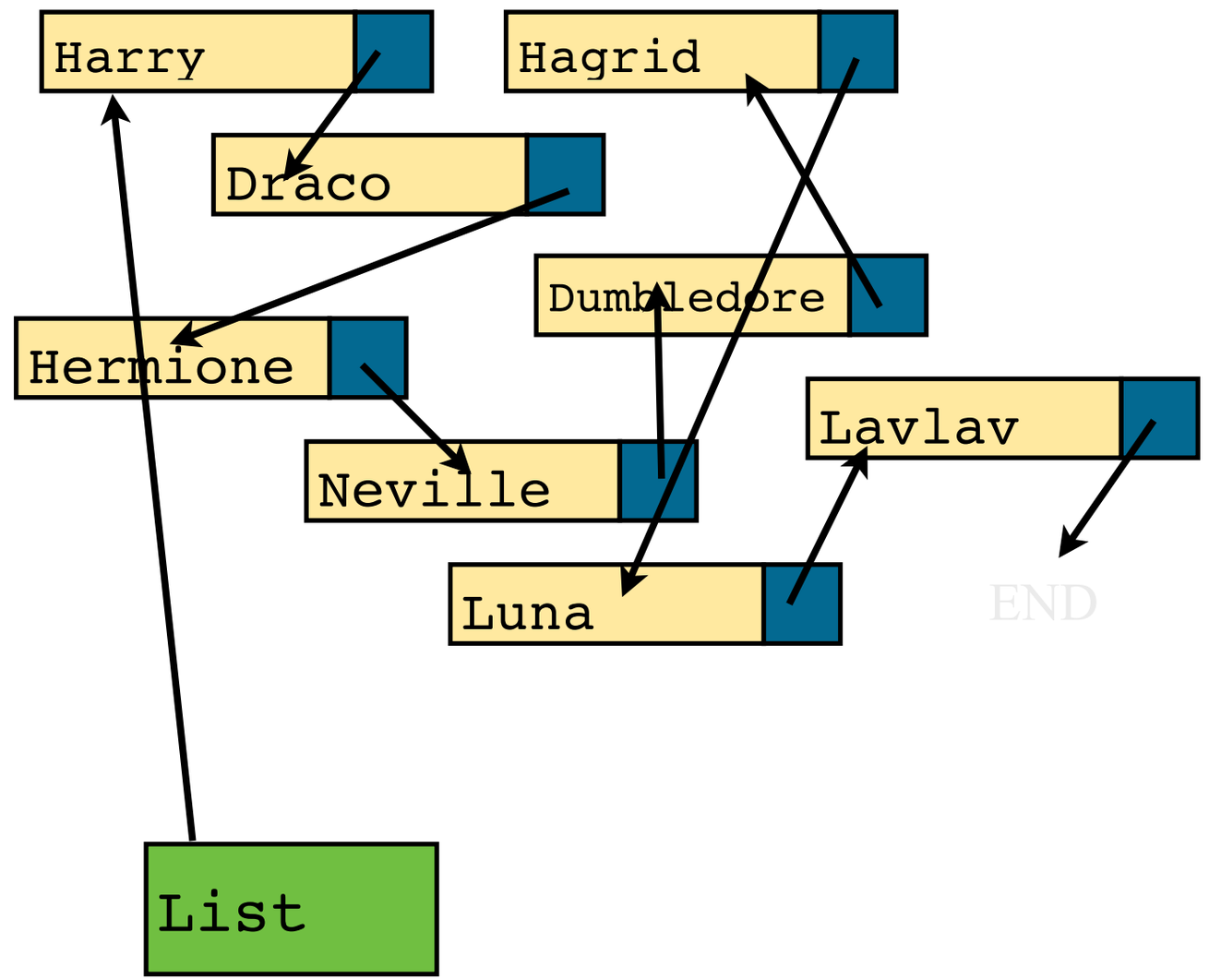


What data do we need?

- How should we represent the list?

- Node data type
  - Name
  - House
  - Wand type
  - Next node

- List data type
  - First Node in list



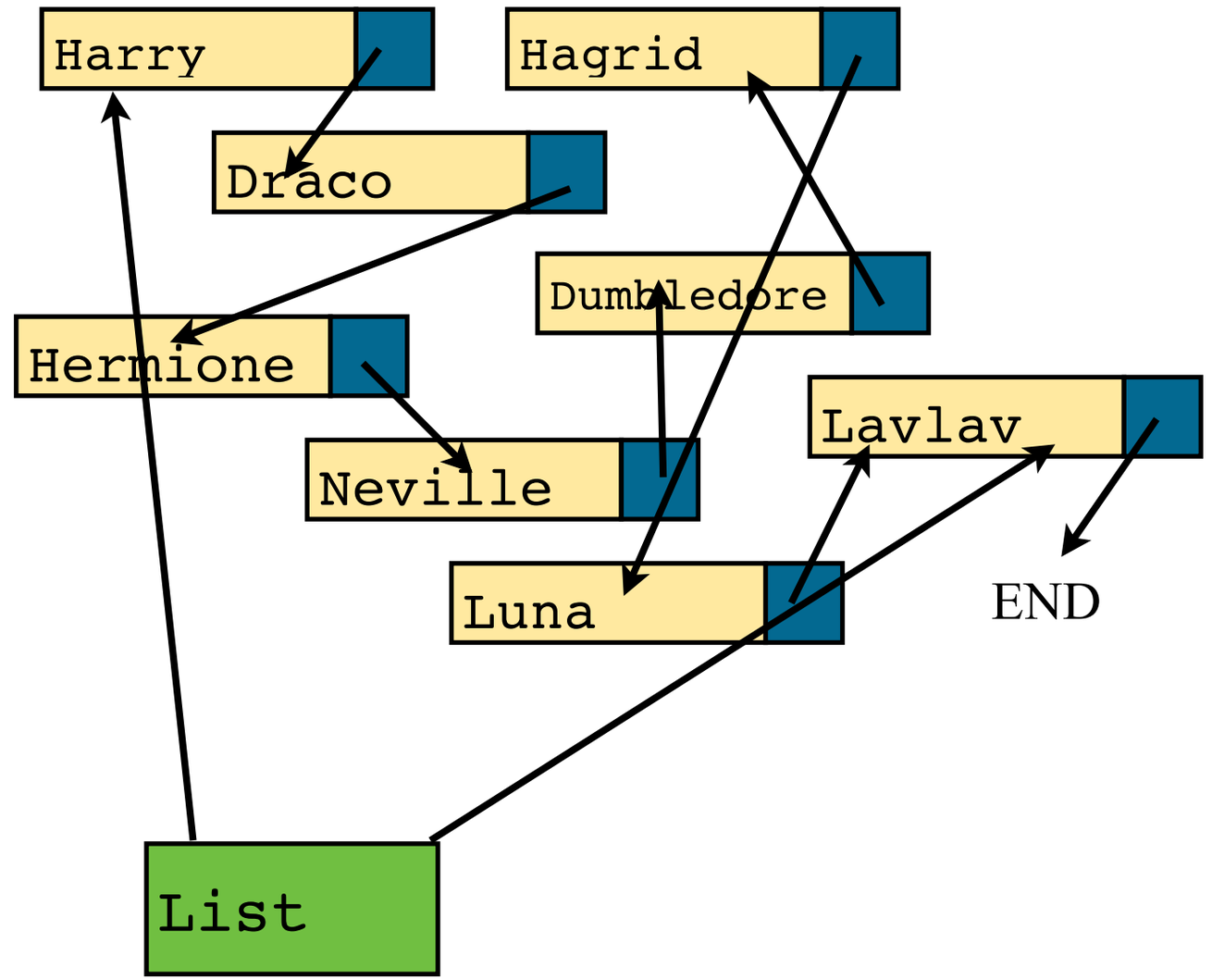
What data do we need?

- How should we represent the list?

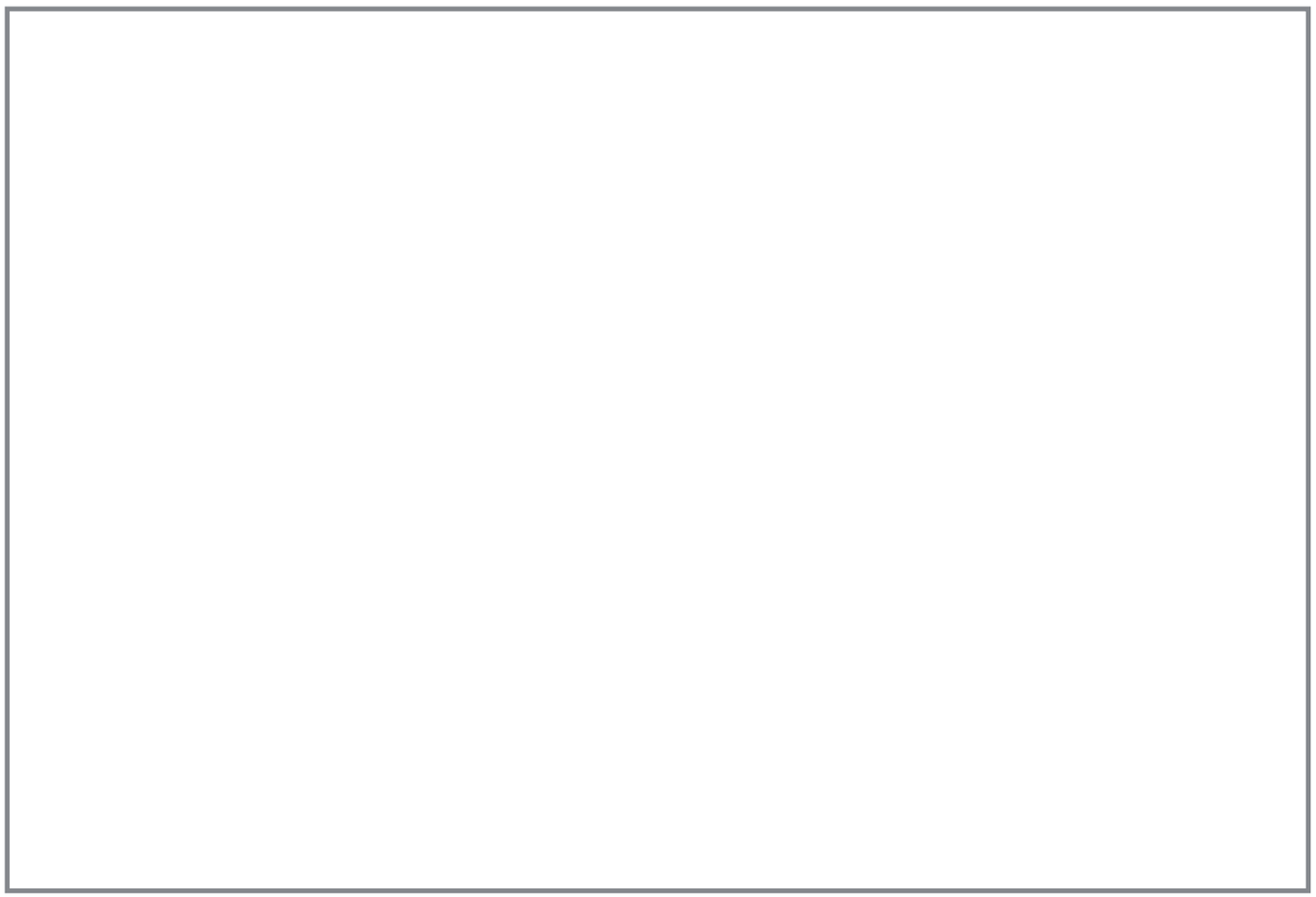
- Node data type
  - Name
  - House
  - Wand type
  - Next node

- List data type
  - First Node in list
  - Last Node in list
  - Count of nodes, etc

Dynamic Linked List



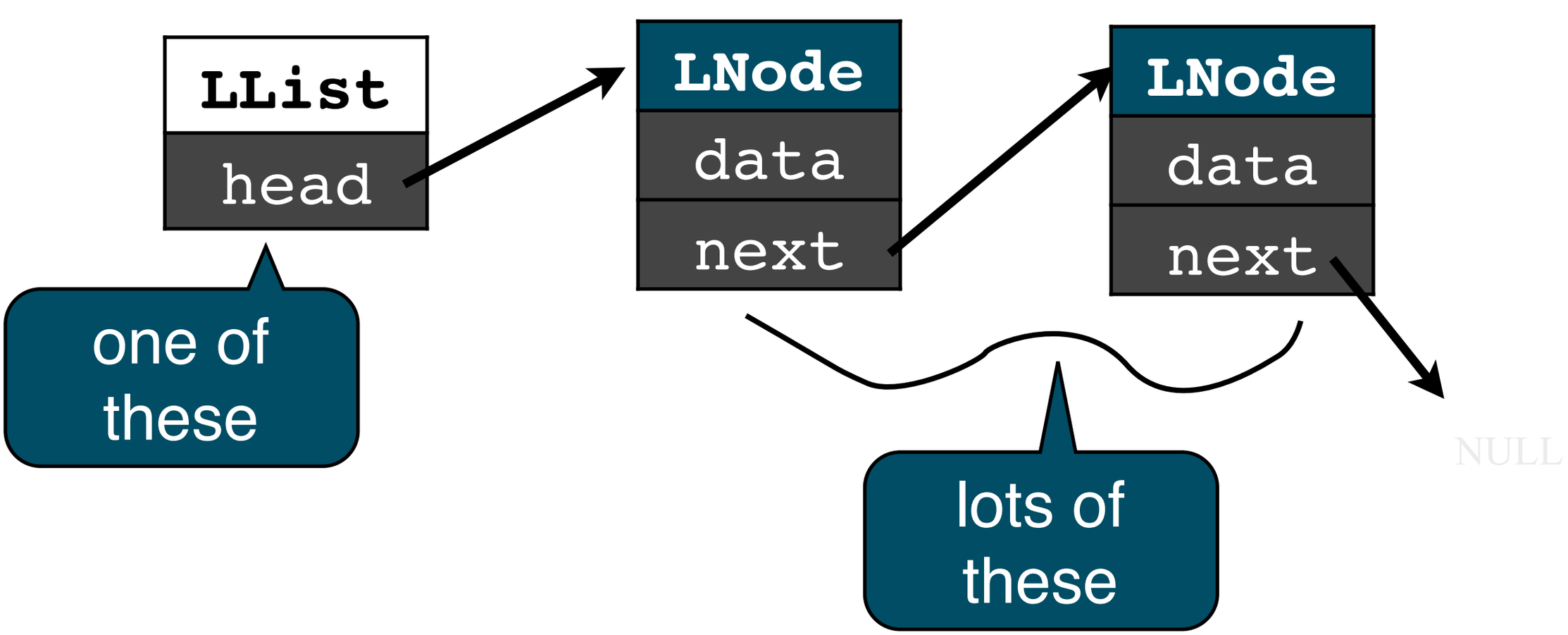
LL: Functions + Data



- Node data type
  - Name
  - House
  - Wand type
  - Next node
- List data type
  - First Node in list

A Linked List in C

- We will use two types of structs
  - **`LList`**: represents the list as a whole, used by application
  - **`LNode`**: used for each entry in the list, stores actual data
- This gives a nicer API than requiring programmer to understand internals of LNodes



A Note on NULL

- NULL is a reserved keyword in C
  - Often used as a "**sentinel**" to tell whether a pointer has been initialized

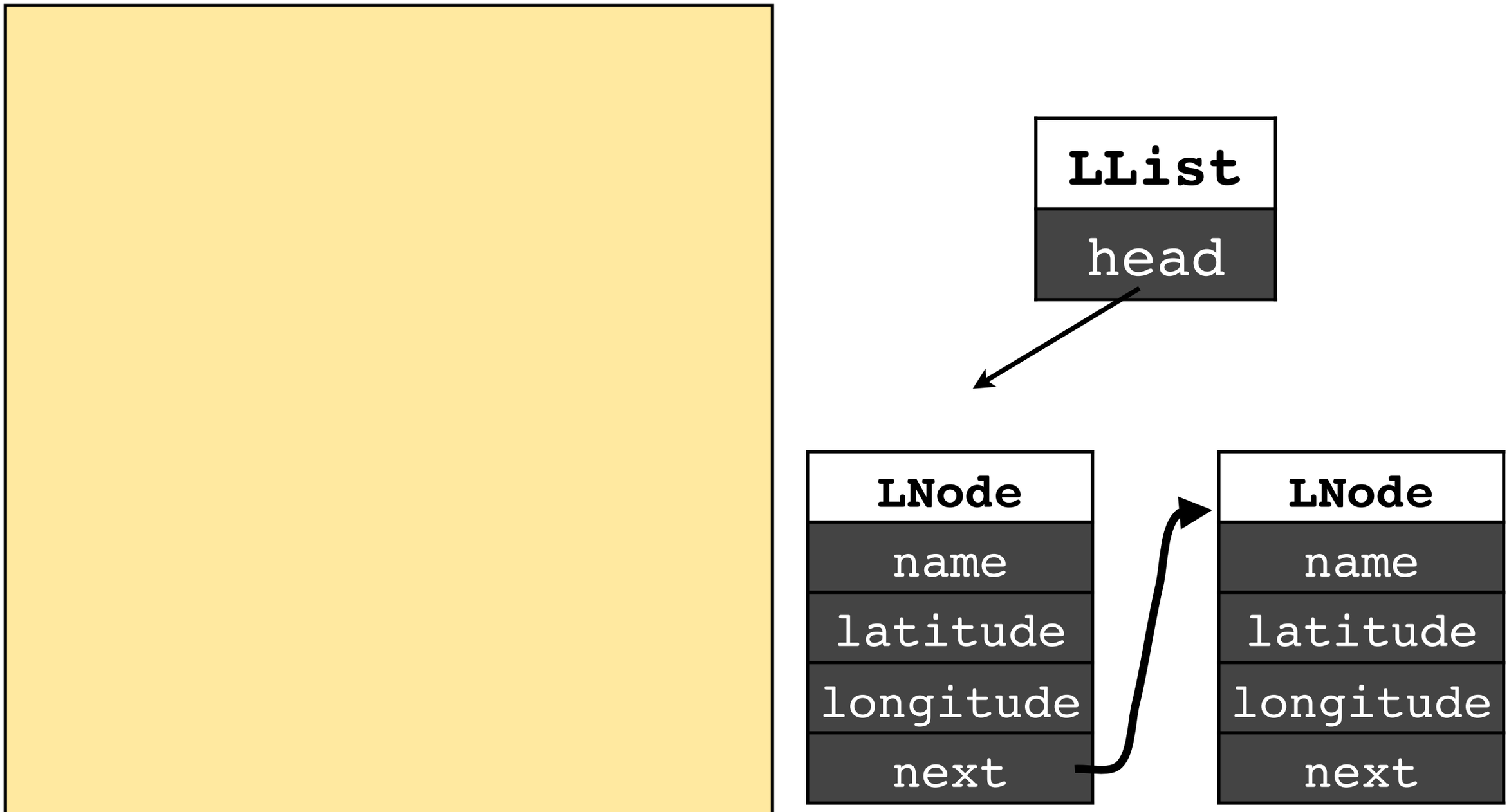
- Are undefined variables automatically set to NULL in C?
  - No!

- We will have to carefully set pointers to NULL by ourselves!

- Secret: NULL is actually just the number 0!

Coding a Linked List

- What is a linked list made of?



Linked Lists and Memory

```
struct LNode {
  int data;
  LNode* next;
};
```

```
struct LList {
  LNode* head;
};
```

```
int main() {
 struct LList* list;
 struct LNode *a, *b;
 list = NULL;
 a = NULL; b = NULL; c = NULL;

}
```

Stack

Address	*Name*	*Contents*
10000		
10004		
10008		
10012		
10016		

Heap

Address	*Alloc?*	*Contents*
50000		
49996		
49992		
49988		
49984		
49980		
49976		
49972		
49968		

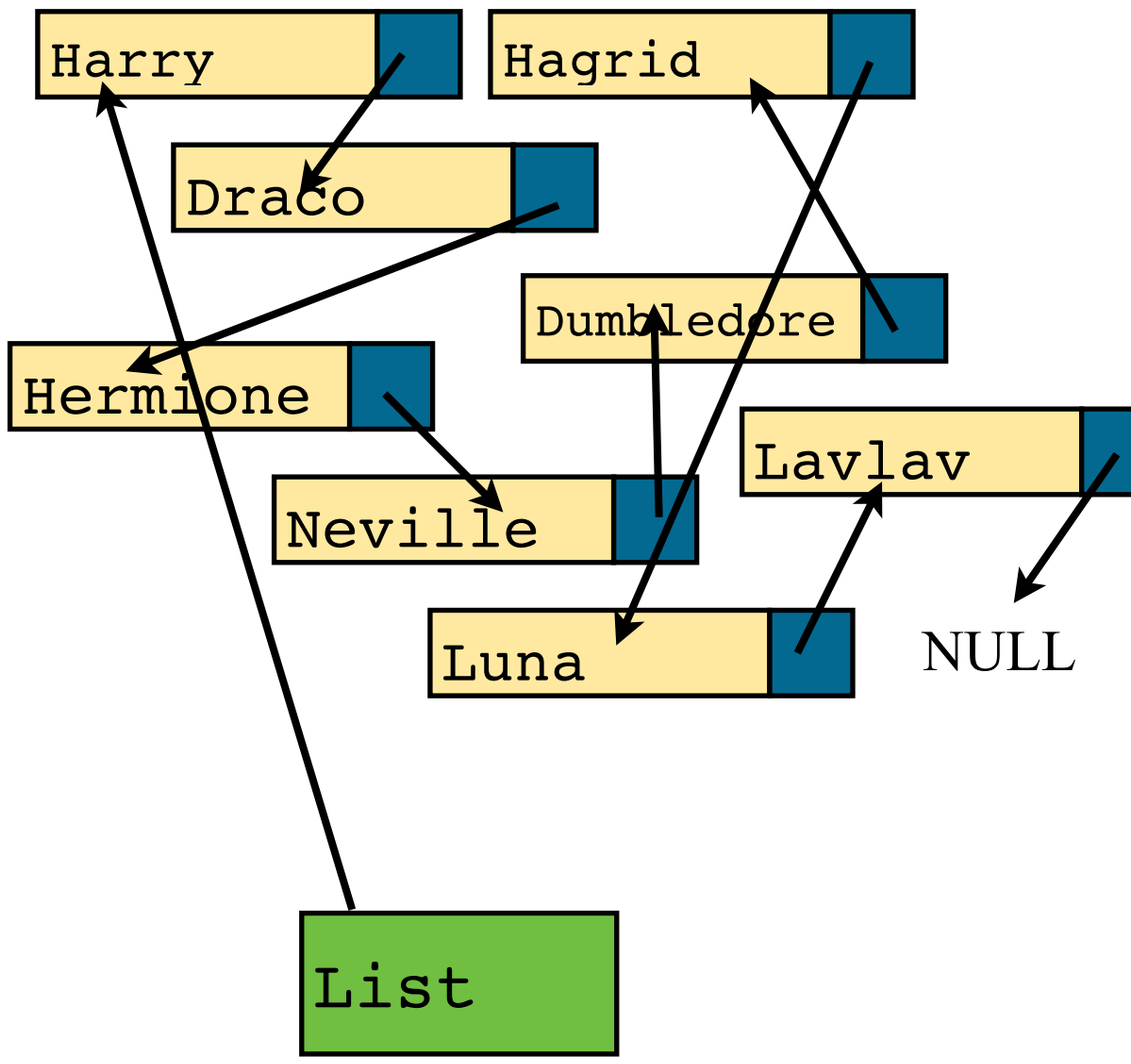
Assume ints and pointers take 4 bytes.

Algorithm to print a LList

- What steps do we need to take?
  - Don't worry about C syntax

```
// in class solution
input: list we want to print
return if the list is empty
go to first node and print it
while there is a next node
   go to the next node
  print that node
```

```
Edge cases:
 - last node (include and stop)
 - empty list
```



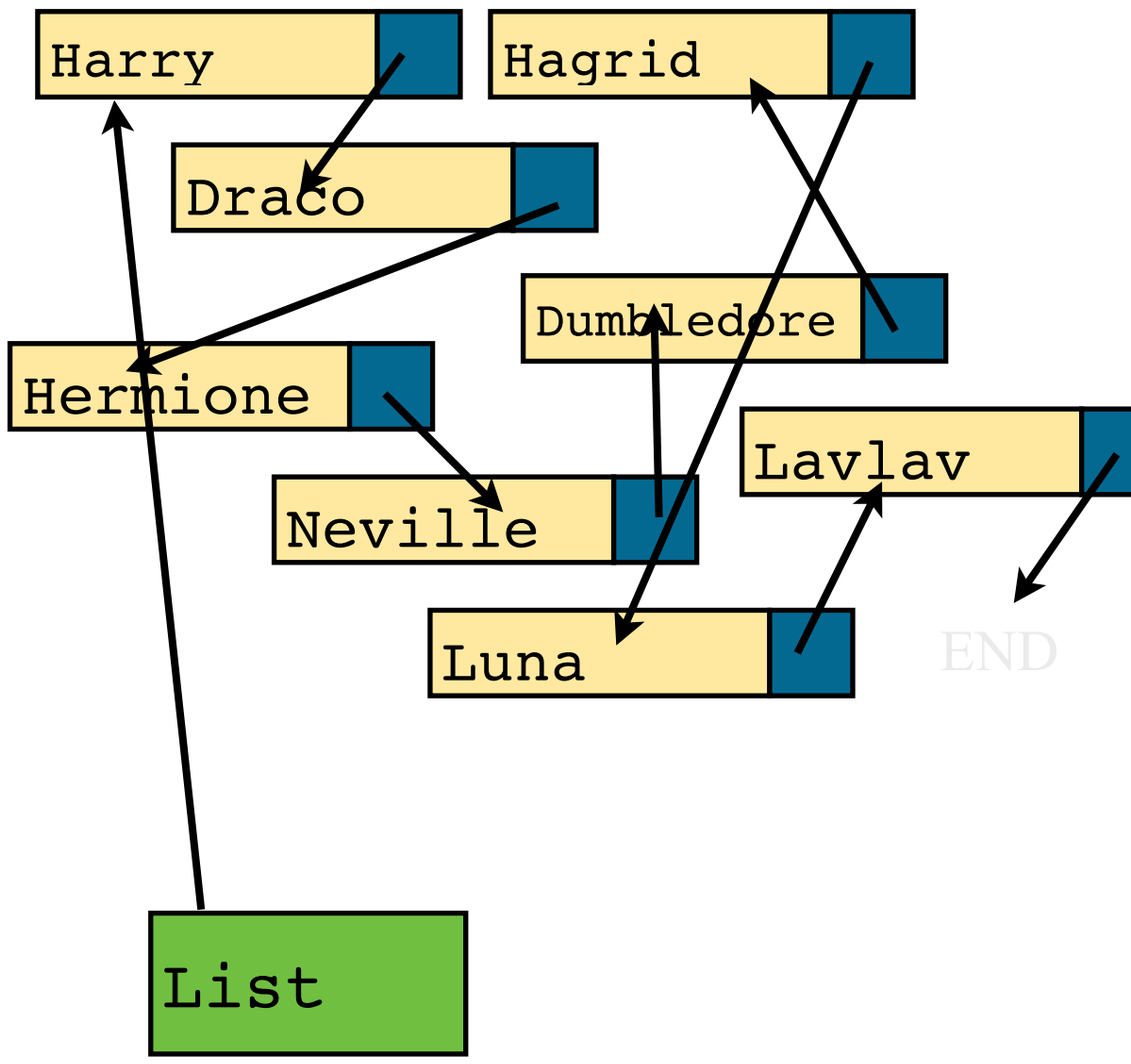
Algorithm to print a LList

- What steps do we need to take?
  - Don't worry about C syntax

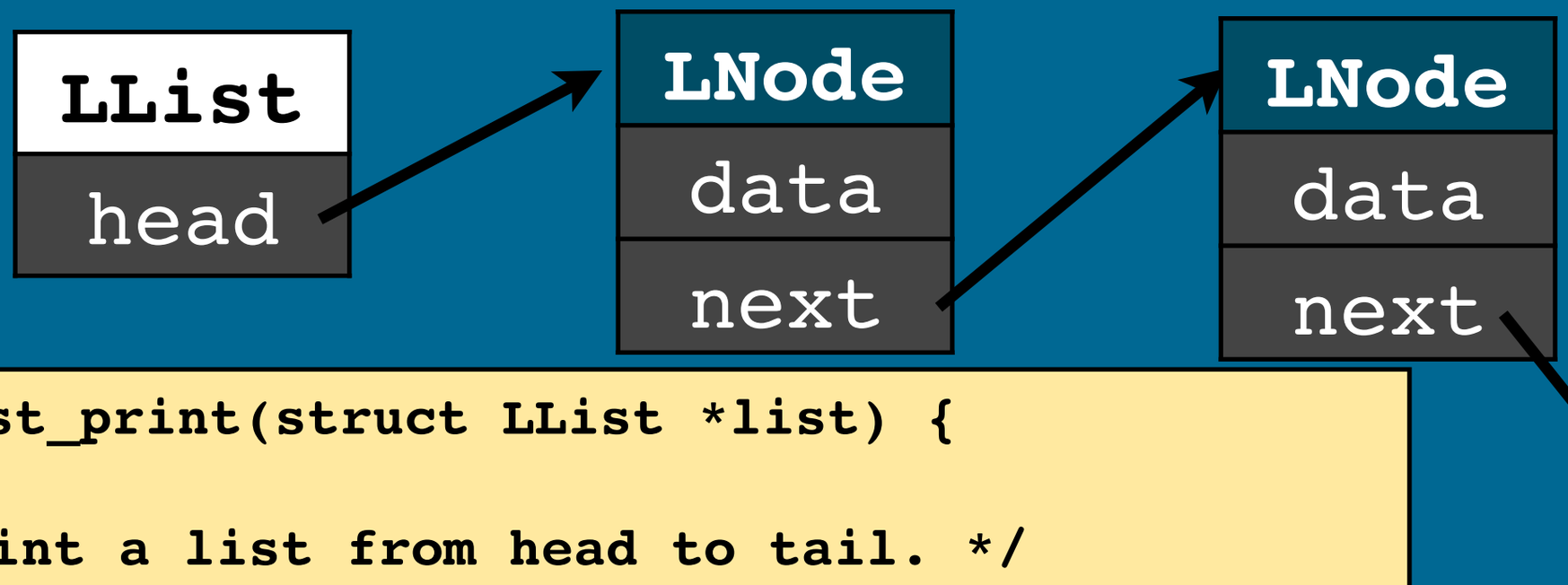
```
Point at the first node in
the list

Start loop...
  Print out the data for the
current node
  If the next node in the
list is empty, exit
```

Edge cases:
Uninitialized List
Empty list
End of list



Printing out a L.L.

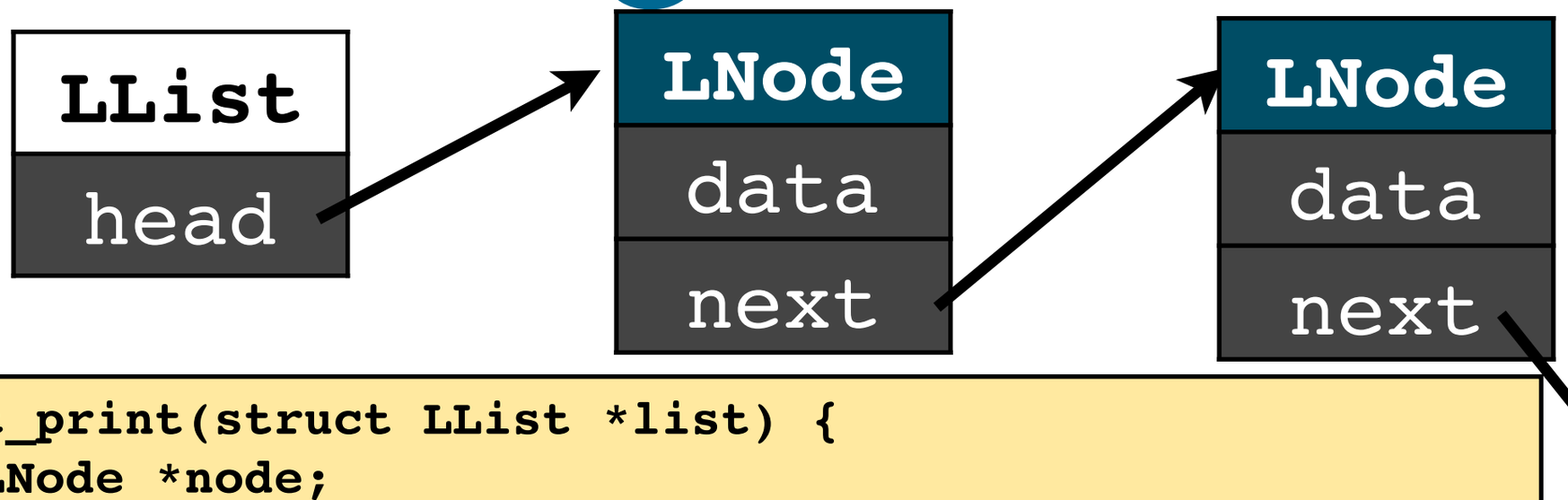



```
void LList_print(struct LList *list) {
{
    /* Print a list from head to tail. */
    if(list == NULL || list->head == NULL) return;
    struct LNode *p = list->head;
    print(p);
    while(p->next != NULL) {
        p = p->next;
        print(p);
    }

}
```

input: list we want to print
return if the list is empty
go to first node and print it
while there is a next node
  go to the next node
  print that node

Printing out a L.L.




```
void LList_print(struct LList *list) {
  struct LNode *node;
  int i = 0;
  if (list == NULL)
    return;
  node = list->head;
  if (node == NULL)
    return;
  while(1) {
    i++;
    printf("%d: %d\n", i, node->data);
    node = node->next;
    if(node == NULL) {
      break;
    }
  }
}
```

C-ish Languages

- C++
  - Enhances C with support for objects and classes
  - Adds the Standard Template Library (STL) for data structures
  - Slightly more flexible language
  - Just as powerful... just as dangerous
- Objective C and Swift
  - Primarily used by Apple
  - Superset of C
  - Adds objects to C in a more confusing way than C++ / Java
  - Extensive library support and custom IDE makes it more bearable
    - So does the potential for earning millions on the App Store!

Moving to Java

- Java Syntax
  - You should already know this...
  - Use book to refresh on basics

- The textbook is "Head First Java" (2005 edition)
  - Readings will be assigned each week
  - **Read them before LAB**
  - **or else...**

Java

- What is it?
  - Object oriented programming language
  - A compiler and run time environment

- Java Virtual Machine (JVM)
  - Interprets your Java code and translates it for your OS & HW
  - Compile your code once, run it anywhere

Why Java?

"A simple, object-oriented, distributed, interpreted, robust, secure, architecture-neutral, portable, high-performance, multithreaded, dynamic language."

Why Not Java?

- Java takes the "lowest common denominator" approach to supporting OS features
  - JVM must be cross platform, so cannot exploit specifics
- For efficient, high-performance scientific code, it's better to use C/C++
  - Memory management in Java is the main slowdown
- For low-level system stuff, you have to use C/C++
  - The Windows or Linux OS can't be run inside a JVM...

The Real Reason…

- Java has become hugely popular:

  Language encourages good programming practices

- Objects, type checking, automated memory management, and run-time system
  - Prevent bugs or make finding and eliminating them easier

- It will be easier for you to write better code, improving productivity

- But, of course, it's not perfect

The Simplest Java

- Sick of "Hello World" yet?

```
public class HelloWorld {

    public static void main (String[] argv)
    {
        String s = "Hello World!";
        System.out.println(s);
    }

}
```

- Must be put in a file called "HelloWorld.java"
  - Unlike C, file name is important and must match class name
- Program start point: **`public static void main(...)`**

Primitive Data Types

- Java has the same basic data types as C
  - `short, int, long, float, double, char`
    - No unsigned types
- Plus two more
  - `byte` (8 byte number) and `boolean` (T or F)

- All data types (except Boolean) have a precisely defined size on all platforms
  - Different from C where size depends on architecture: 16 vs 32 vs 64bit `ints`
- All variables are initialized to zero, false, or null

Java Primitives

FIGURE 3-1 **Primitive types in Java**

Type	Domain	Common operations
`byte`	8-bit integers in the range –128 to 127	*The arithmetic operators:* `+` add `*` multiply `-` subtract `/` divide `%` remainder *The relational operators:* `==` equal `!=` not equal `<` less than `<=` less or equal `>` greater than `>=` greater or equal
`short`	16-bit integers in the range –32768 to 32767	
`int`	32-bit integers in the range –2147483648 to 2147483647	
`long`	64-bit integers in the range –9223372036854775808 to 9223372036854775807	
`float`	32-bit floating-point numbers in the range $\pm 1.4 \times 10^{-45}$ to $\pm 3.4028235 \times 10^{38}$	*The arithmetic operators except* `%` *The relational operators*
`double`	64-bit floating-point numbers in the range $\pm 4.39 \times 10^{-322}$ to $\pm 1.7976931348623157 \times 10^{308}$	
`boolean`	the values `true` and `false`	*The logical operators:* `&&` and `||` or `!` not
`char`	16-bit characters encoded using Unicode	*The relational operators*

Source: Art & Science of Java http://people.reed.edu/~jerry/121/materials/artsciencejava.pdf

Compiling and Running

- **`javac`** = compiler

```
$ javac HelloWorld.java        # prints nothing on success
$ ls
HelloWorld.class     HelloWorld.java
```

- Differences from C:
  - Standard names---always becomes `<ClassName>.class`
  - Each class gets its own compiled file (not just `a.out`)
  - .class file is java bytecode---must be interpreted by the JVM
    - Not platform specific assembly instructions

- **`java`** = run time

```
$ java HelloWorld          # class name to run
Hello World!
```

Pro Tip

- In Unix/Linux if you want to match several file names you can use the * symbol

```
$ javac *.java
$ ls
// Every .java file will now be compiled into .class
// or you will see lots of errors
```

Linked List and Java

- How do we transform C to Java?

```
struct LNode {
  int data;
  LNode* next;
};
```

```
struct LList {
  LNode* head;
};
```

```
int main() {
 struct LList* list;
 struct LNode *a, *b, *c;
 list = NULL;
 a = NULL; b = NULL; c = NULL;
 list = malloc(sizeof(struct LList));
 a = malloc(sizeof(struct LNode));
 b = malloc(sizeof(struct LNode));
 c = malloc(sizeof(struct LNode));
 list->head = a;
 a->data = 45;
 a->next = b;
 b->data = 89;
 b->next = c;
 c->data = 52;
 c->next = NULL;
}
```

Objects and Classes in Java

- In Java:
  - A class is type of object
  - All objects have a class
  - Primitives (int, float, etc) and functions are not objects

```
public class Hello {
   public static void main (){
        System.out.println("hi.");
     }
}
```

- Classes contain data and functions
  - An object instantiates that data
- Class Constructor
  - Used to create new objects
  - Initialize variables

```
public class Car {
   public int x;
   public int y;

   public Car(int x, int y) {
      this.x = x;
      this.y = y;
   }
   public void draw() {
      // make a picture
   }
```

Working with objects

```
public class Car {
   public int x;
   public int y;

   public Car(int x, int y) {
      this.x = x;
      this.y = y;
   }
   public void draw() {
      // make a picture
   }
   public static void main (){
     Car mercedes;

     mercedes.x = 34;
     mercedes.y = 11;
     mercedes.draw();
   }
}
```

- Does this code work?

Creating `new` Objects

- To use an object we need a reference to it
- Use the **`new`** command to instantiate an object
- What do you think is happening in memory?

```
public static void main(...)
{
   Car chevy;
   Car honda;
   honda = new Car(10, 20);
```

Creating `new` Objects

- To use an object we need a reference to it
- Use the **`new`** command to instantiate an object
  - Reserves memory on the **Heap** for that object class
- Each new object gets its own chunk of memory
  - But they share functions and static class variables

```
public static void main(...)
{
   Car chevy;
   Car honda;
   honda = new Car(10, 20);
```

Stack

chevy	null
honda	0x1423000

Heap

0x1423000	x	10
0x1423004	y	20