CS134 Lecture 29:

Special Methods & Linked Lists

Announcements & Logistics

- **HW 9** due Monday @ 10 pm on GLOW
  - Short: 6 questions for practice on OOP concepts
- **Lab 9 Boggle**: two-week lab now in progress
  - **Part 1** auto-tester feedback will be returned today
  - You can fix anything broken before turning in Part 2
  - **Part 2** due May 1/2 (handout posted)
  - Part 2 also has a **prelab!**
    - Asks you to draw out the Boggle game logic

Do You Have Any Questions?

Last Time

- Finished implementation of **Tic Tac Toe game**
    - (Fun?) Application of object-oriented design and inheritance
    - A little exposure to software design
- Designed to help with the **Boggle lab**

Today's Plan

- Discuss special methods, their purpose and how to that call them
- Build a **recursive list class**
    - Our own implementation of `list`!
    - Preview of the fun world of design and implementation of data structures
- Learn how to implement several **special methods** which let us utilize built-in operators in Python for user-defined types

Python's Built-in list Class

- A class with methods (that someone else implemented)
- `pydoc3 list`
- Let's implement our own list class with similar functionality

```
Help on class list in module builtins:

class list(object)
 |  list(iterable=(), /)
 |
 |  Built-in mutable sequence.
 |
 |  If no argument is given, the constructor creates a new empty list.
 |  The argument must be an iterable if specified.
 |
 |  Methods defined here:
 |
 |  __add__(self, value, /)
 |      Return self+value.
 |
 |  __contains__(self, key, /)
 |      Return key in self.
 |
 |  __delitem__(self, key, /)
 |      Delete self[key].
 |
 |  __eq__(self, value, /)
 |      Return self==value.
 |
 |  __ge__(self, value, /)
 |      Return self>=value.
 |
 |  __getattribute__(self, name, /)
 |      Return getattr(self, name).
 |
 |  __getitem__(...)
 |      x.__getitem__(y) <==> x[y]
 |
 |  __gt__(self, value, /)
:
```

Notice the double underscores: these are special methods

Special Methods/Magic Methods

Special Methods

- Start and end with __ (double underscore)
  - Called **magic methods** (or informally dunder methods)
- Often not called explicitly using dot notation and called by other means
- What special methods have we already used seen/used so far?
- **`__init__(self, val)`**

- When is it called?
  - Automatically when we ***create*** an instance (object) of the class
  - Can also be invoked as `obj.__init__(val)` (where `obj` is an instance of the class)

Special Methods

- **`__str__(self)`**
  - When is it called?
    - When we ***print*** an instance of the class using `print(obj)`
    - Also called whenever we call `str` function on it: `str(obj)`
    - Can also be invoked as `obj.__str__()`
- **`__repr__(self)`**
  - Also returns a string but its format is very specific (can be used to recreate the object of the class)
  - Useful for debugging
  - Don't worry about any more specifics for this method for CS134

Special Methods for Operators

- We can use mathematical and logical operators such as `==/+` to compare/add two objects of a class by defining the corresponding special method
- Example of polymorphism (using a single method or operator for different uses)
  - `__eq__ (self, other):` `x == y`
  - `__ne__ (self, other):` `x != y`
  - `__lt__ (self, other):` `x < y`
  - `__gt__ (self, other):` `x > y`
  - `__add__(self, other) :` `x + y`
  - `__sub__(self, other):` `x - y`
  - `__mul__(self, other):` `x * y`

__add__: why we can concatenate sequences with **+** as well as add ints with **+**

- There are many others!

Special Method: `__len__`

- **`__len__(self)`**
  - Called when we use the built-in function `len()` in Python on an object `obj` of the class: `len(obj)`
  - We can call `len()` function on any object whose class has the `__len__()` special method implemented
    - All built-in collection data types we saw (string, list, range, tuple, set, dictionaries) have this special method implemented
    - This is why we are able to call `len` on them
- What is an example of a built-in type that we can't call `len` on?
  - `int, float, Bool, None`

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 |  __gt__(self, value, /)
:
```

Other sequence specific methods:
`__getitem__`

Other Special Methods for Sequences

- What other sequence operators have we used in this class?
- They each have a special method that is called whenever they are used
  - **Get** an item at an index a sequence using `[ ]:` calls `__getitem__`
    - e.g., `word_lst[2]` implicitly calls `word_lst.__getitem__(2)`
  - **Set** an item at an index to another `val` using `[ ]`: calls `__setitem__`
    - e.g., `word_lst[0] = "hello"` implicitly calls `word_lst.__setitem__(0, "hello)`

`in` Operator: `__contains__`

- **`__contains__(self, val)`**
  - When we say `if elem in seq` in Python:
    - Python calls the `__contains__` special method on `seq`
    - That is, `seq.__contains__(elem)`
  - If we want the `in` operator to work for the objects of our class, we can do so by implementing the `__contains__` special method

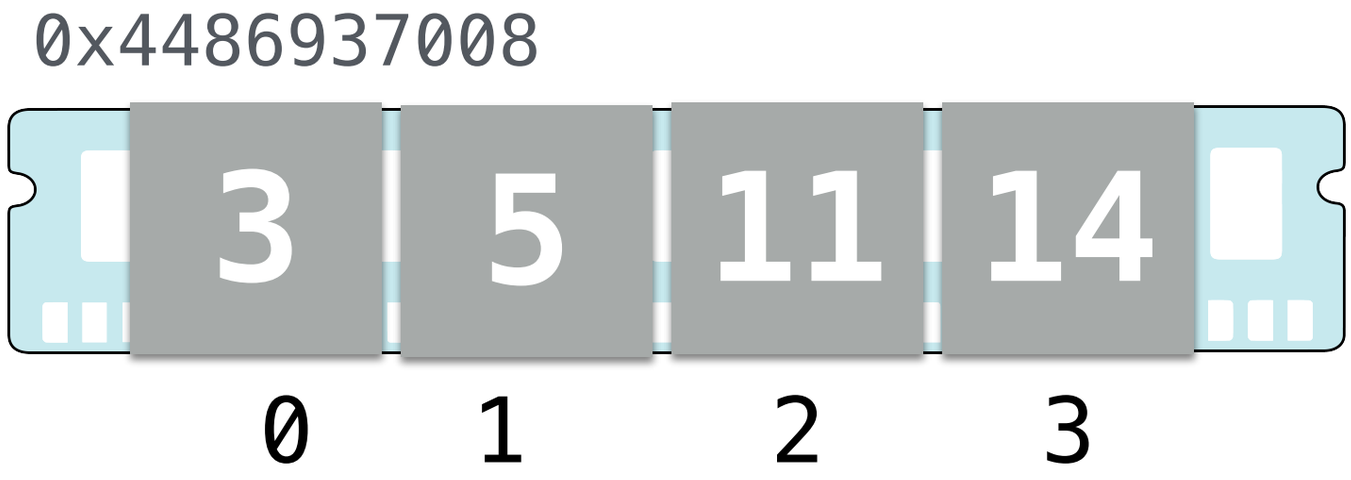
Building Our Own Sequence Type

How to Store a Sequence

- A sequence is just an **ordered collection** of values
    - Can query for the 0th, 1st, 2nd item and so on..
- A sequence may be mutable or immutable
- Let's think about how we can design such a sequence
    - How to store these ordered values?
- Let's look at two options

Array: Contiguous Sequence

- Option 1: Just store the items contiguously in memory
- Such a sequence is called **an array** in computer science
- To access a `item`, just need to know where the array starts and the **index** of item in array
- Great for static sequences!



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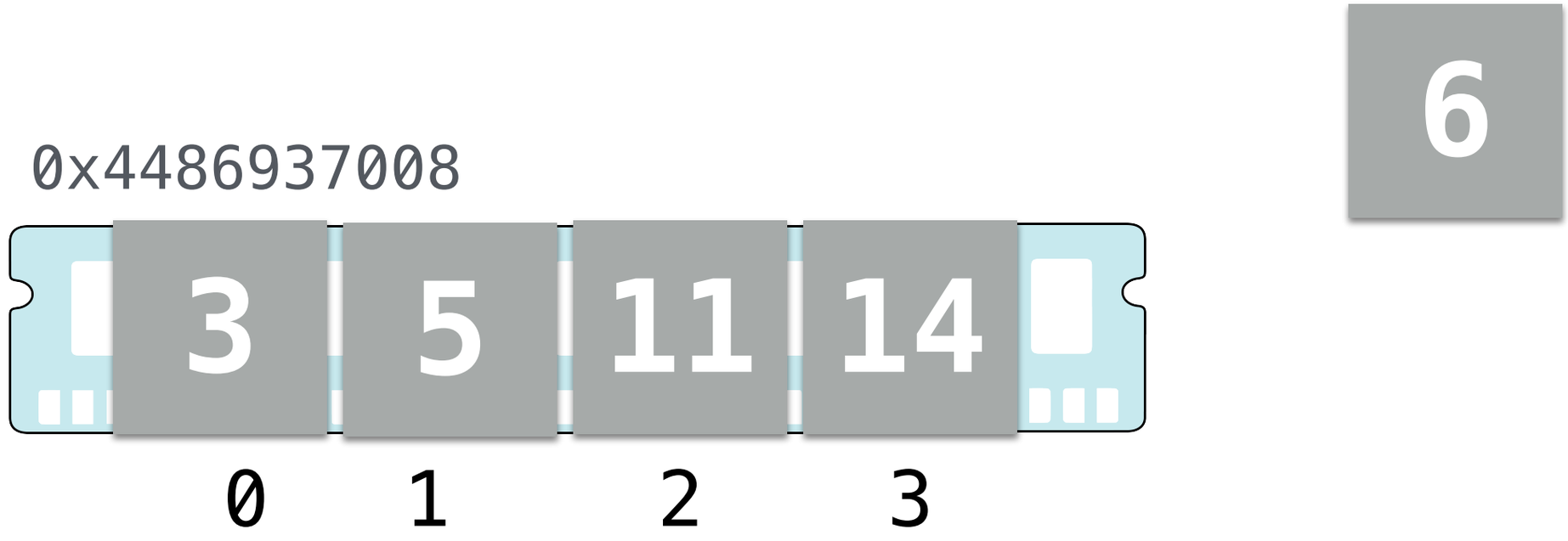
- Suppose we want to create a dynamic sequence
- Want to be able to insert: e.g. want to insert 6 between 5 and 11



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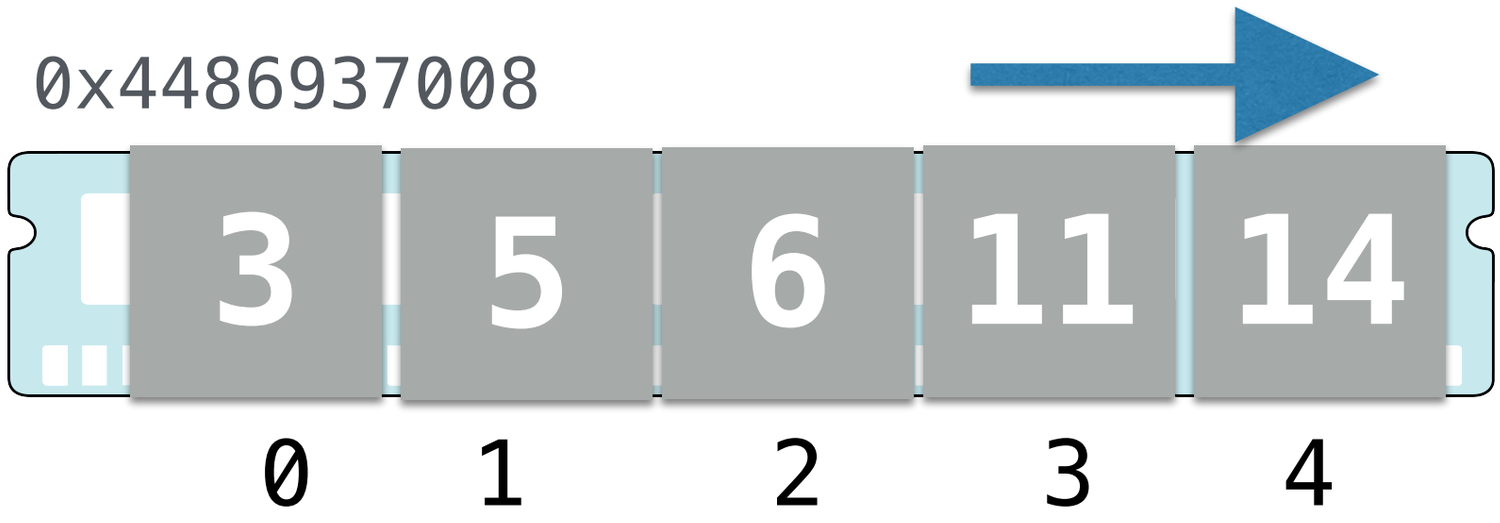
- Suppose we want to create a dynamic sequence
  - Want to be able to insert: e.g. want to insert 6 between 5 and 11
  - Need to move everything over by one to make space

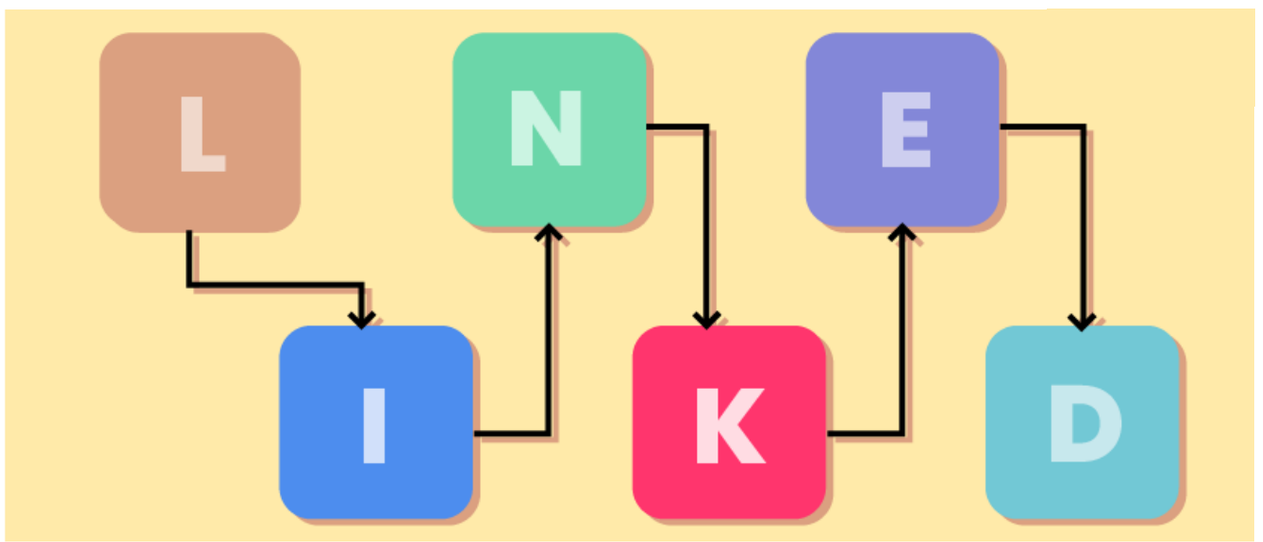


Insert Efficiently?

- If our array is made up of millions of items and we need to insert a lot:
    - Expensive to maintain ordering in an array
    - Maybe we need a different way to store items
- All we care about is that items are in order:
    - Each item has a item before it or after it in the sequence
    - Knowing this is sufficient to recover the total ordering, why?

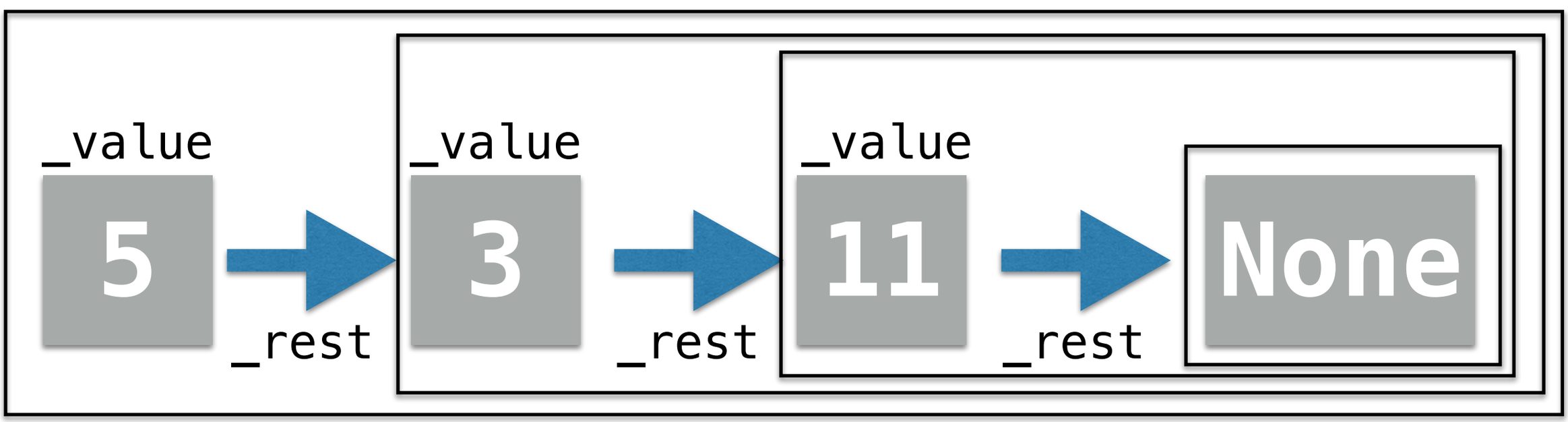
Linked List

- Another way to design an ordered mutable sequence:
    - A nested *chain* of values, or a **linked list**
    - Each value has something after it: the rest of the sequence
- Must have a last item for a finite sequence
    - To signify last item it's next value should be **nothing**
    - What is a good type to represent nothing in Python?



Our Own Class `LinkedList`

- Attributes:
  - `_value, _rest`
- **Recursive class**:
  - `_rest` points to another instance of the ***same class***
  - Any instance of a class that is created by using another instance of the class is a ***recursive class***



Next Time: Code for Linked List