Generics and Dictionaries

Instructors: Sam McCauley and Dan Barowy

February 21, 2022

Admin

- Remember to do the reading! (We may ask about it on quizzes, especially on Monday)

Admin: Masking

- Instructors now allowed to unmask in classrooms???
- We'll send around a google form after all three lecture sections
- Idea: gauge what you all think. We really have no idea where all of you are coming from, so hard to make a decision until then
  - (Not a poll; just trying to get high-level idea)
- We don't really mind masking. Want to ensure best possible experience for you.
- Only lectures! We'll continue all masking in labs, office hours, etc.

Wordgen Lab

- Any questions?
- If you’re still working on it, be sure to make time to attend TA hours over the next couple days.
- Almost definitely one of the harder labs in the course! But you’re almost there.

Today

- How can we create a `Vector` class?
- Look at how the actual `Vector` class is created
- Start time and space analysis, as well as asymptotics

Building the `Vector` class

Creating a `Vector` class

- You have everything you need to create your own `Vector`s!
- Let's work through it together. (Then we'll look at the `structure5` code and see how we did.)
- Goal: hold sequence of items. Should be able to handle `add(E)`, `get(int)`, `set(int, E)`, `contains(E)`
- Use generics to handle any type of item

Designing the class

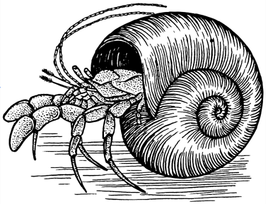
- What questions should you ask yourself when you start thinking about how to design a class?
  - What data does this class need to store? How should we store it?
  - What methods do we want to use to interact with this data?

A caveat about Generics: arrays don't work

- Cannot create an array of a generic type in Java
  - Due to some back-end issues with how generics are implemented
- What can we do instead?
- Create an array of type `Object`. Handle casting manually.
- Good news: we do the casting in the `Vector` class. This issue is invisible to the end user!

```
private E[] items; //not allowed! Will give an error
private Object[] items; //allowed! We have to do casting, etc. manually
```

Thinking about Storing the Data



- What does an array not support that a `Vector` does?
- Need to declare the size of an array up front. But don't need to for `Vector`!
- How can our `Vector` class deal with this?
  - Let's start with an array of size 10. What do we do when it fills up?
  - Answer: allocate a bigger array and copy it over!
  - Let's create a method that does this for us: checks if there's enough room in the array, and grows it if not. We can call this `ensureCapacity(int minCapacity)`. We'll come back to this; let's fill in some methods in the meantime.

Drafting the `Vector` methods

- Let’s write `add`, `set`, `get`
- Don’t forget to cast when appropriate!
- Once we have these we can test.
- Finally, let’s write `contains`

Ensuring the Capacity

- If the array is too small, how large should we make it?
- One option: make it `minCapacity` size
- Another option: double its size (until large enough)
    - Downside: wastes space
    - Upside: much longer until we have to resize it again
    - We'll see on Friday that doubling leads to much better performance
- Let's write out `ensureCapacity`

`public` vs `private` methods

- The methods we use to interact with the data stored in an object have to be `public` (so that they can be called)
- But methods that are only used internally should be `private`
- Which would you say `ensureCapacity` is?
- Somewhat debatable, but probably private. Only make the array larger when necessary to carry out operations like `add`.
- All done! Let’s test. Then, let’s quickly check what our work looks like compared to the `structure5` implementation

Time and Space Analysis

How efficient is a given method?

- We saw how to do `contains` in a `Vector`. How many items did we have to look through in the worst case?
- Let's say I'm looking through a literal dictionary. Is my contains method very efficient? Do you have a faster way?
- What if I say I'm a really fast reader. Is your method still faster?
  - Probably
  - Unless the dictionary is really short. A fast reader may be able to read through a dictionary with 10 elements better than a more clever search method
- Idea here: analyze the efficiency of a *methodology*. Your speed—or your computer's speed—shouldn't be a factor.

What do we mean by efficiency?

- Perhaps: how long does a method take to run in seconds?
- How much space does it take? (How many bits do we need to store on our computer during the calculation)?

Algorithmic Efficiency

- We are looking for worst-case guarantees
- When you write a piece of code, the goal here is to say “I promise that my code will *always* run efficiently.”
  - It’s a much more widely applicable statement than “I tested my code out and it seems to run efficiently.”
  - What if your tests didn’t take into account a key scenario?

The Challenge of Analyzing Time

- Different computers run at different speeds
- Computers are complicated! Adding two numbers together (for example) can take drastically different times depending on context.
- Good news: often times these details don’t change much
- Example: It doesn’t matter (too much) how fast I read if I’m scanning thousands of extra dictionary pages.