CSCI 136:
Data Structures
and
Advanced Programming

Lecture 21

More iterators

Instructor: Dan Barowy

Williams

Topics

- Iterators
- Integer representation

Your to-dos

1. Read **before Fri**: Bailey, Ch 12.6-12.9.
2. Lab 7 (partner lab), **due Tuesday 4/19 by 10pm**.

Announcements

- **ACM TechTalk: "Visual Data Analysis: Why? When? How?"**
  Organized by Prof. Kelly Shaw and CoSSAC.
  Wednesday, April 13 from 7-7:45pm in TBL 211.
  "Extra special snacks" provided by CoSSAC afterward in the Eco Cafe.
- **This Friday's colloquium**: CS pre-registration info session.

Practice quiz

Integer representation

The bits of an integer

An **integer** is represented in computer memory as a **sequence of bits**, each having a value of either **0** or **1**. This representation is called **binary**.

Binary is number system where each digit can take one of two values; i.e., the **base** of the system is **2**.

You are probably more familiar with the **base 10** number system, aka **decimal**.

Any integer can be represented in either system.

Java `int`

The `int` data type in Java has 32 bits.

00000000 00000000 00000000 00010111

is the number 23.

$$
\begin{aligned}
&(00000000000000000000000000010111)_2 \\
&= (0 \times 2^{31}) + (0 \times 2^{30}) + (0 \times 2^{29}) + (0 \times 2^{28}) \\
&+ (0 \times 2^{27}) + (0 \times 2^{26}) + (0 \times 2^{25}) + (0 \times 2^{24}) \\
&+ (0 \times 2^{23}) + (0 \times 2^{22}) + (0 \times 2^{21}) + (0 \times 2^{20}) \\
&+ (0 \times 2^{19}) + (0 \times 2^{18}) + (0 \times 2^{17}) + (0 \times 2^{16}) \\
&+ (0 \times 2^{15}) + (0 \times 2^{14}) + (0 \times 2^{13}) + (0 \times 2^{12}) \\
&+ (0 \times 2^{11}) + (0 \times 2^{10}) + (0 \times 2^{9}) + (0 \times 2^{8}) \\
&+ (0 \times 2^{7}) + (0 \times 2^{6}) + (0 \times 2^{5}) + (1 \times 2^{4}) \\
&+ (0 \times 2^{3}) + (1 \times 2^{2}) + (1 \times 2^{1}) + (1 \times 2^{0}) \\
&= (23)_{10}
\end{aligned}
$$

Bitwise Operations

We can use bitwise operations to manipulate the `1`s and `0`s in the binary representation

- Bitwise 'and': `&`
- Bitwise 'or': `|`

Also useful: bit shifts

- Bit shift left: <<
- Bit shift right: >>

& and |

Given two integers `a` and `b`, the bitwise or expression `a | b` returns an integer s.t.

- At each bit position, the result has a `1` if that bit position had a `1` in EITHER `a` OR `b`
  - `3 | 6 = ?`

```
011 | 110 = 111
```

Given two integers `a` and `b`, the bitwise and expression `a & b` returns an integer s.t.

- At each bit position, the result has a `1` if that bit position had a `1` in BOTH `a` AND `b`
  - `3 & 6 = ?`

```
011 & 110 = 010
```

>> and <<

Given two integers `a` and `i`, the expression `(a << i)` returns $(a * 2^i)$

- Why? It shifts all bits left by `i` positions
  - `1 << 4 = ?`

```
00001 << 4 = 10000
```

Given two integers `a` and `i`, the expression `(a >> i)` returns $(a / 2^i)$

- Why? It shifts all bits right by `i` positions
  - `1 >> 4 = ?`

```
00001 >> 4 = 00000
```

  - `97 >> 3 = ?`

```
1100001 >> 3 = 1100
```

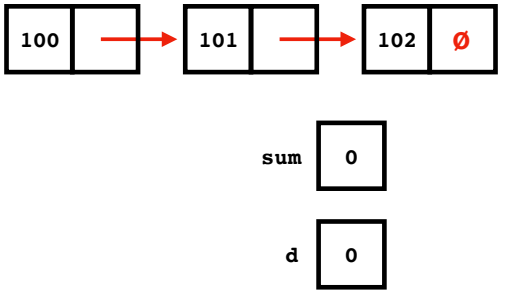
Iterators

Iteration

Iteration is the **repetition of a process** in order to generate a (possibly unbounded) **sequence of outcomes**. Each repetition of the process is a single iteration, and the outcome of each iteration is then the starting point of the next iteration.

Example.

```
List<Double> ls = new SinglyLinkedList<>();
// … initialize ls …
double sum = 0.0;
for (double d : ls) {
  sum += d;
}
```



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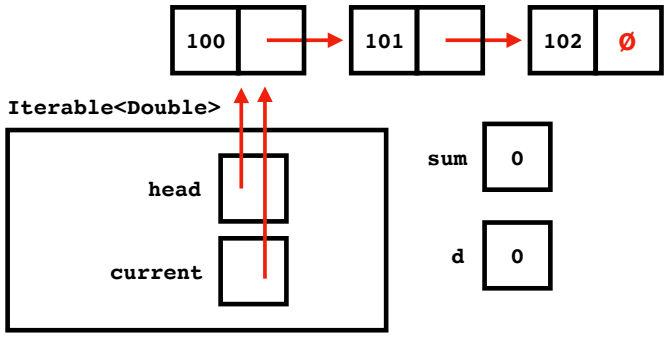

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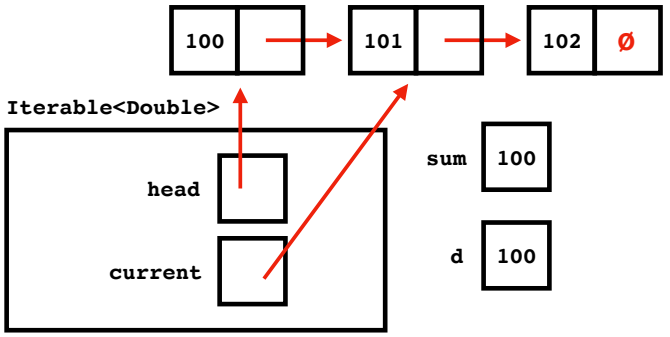

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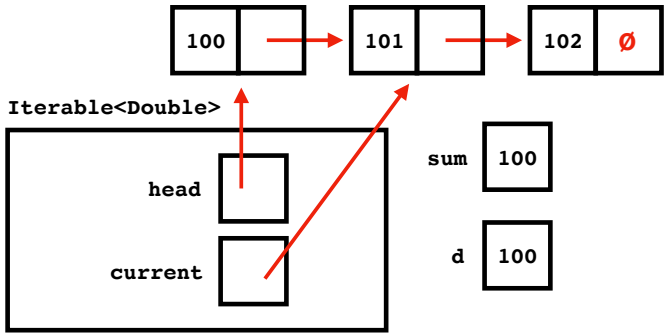

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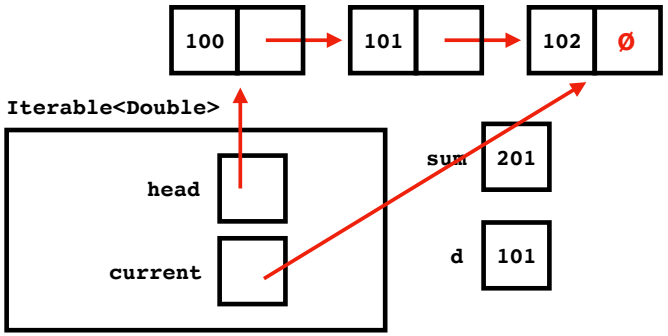

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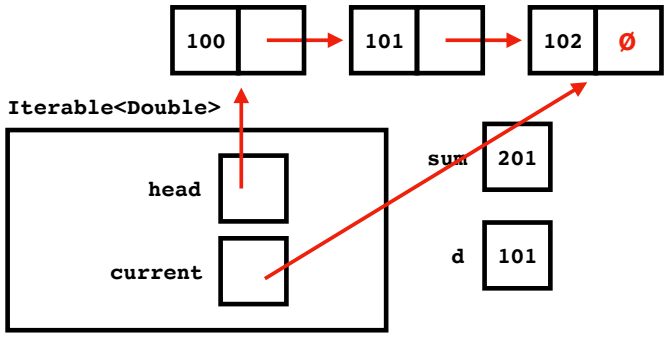

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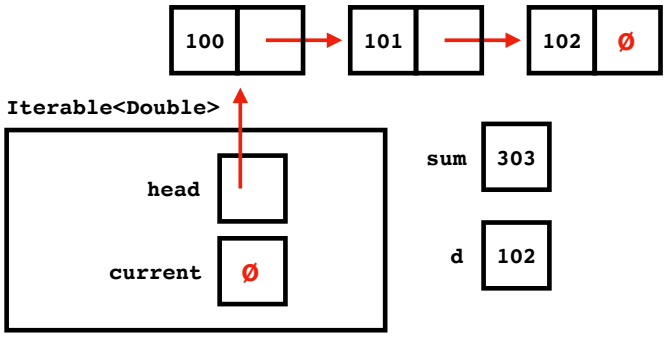

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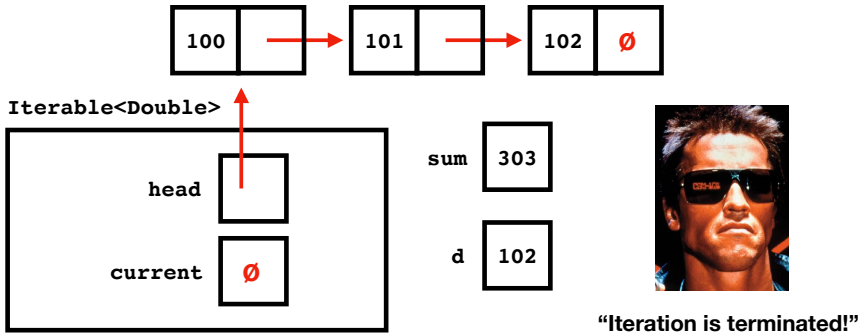

"Iteration is terminated!"

What's an `Iterator<T>`?

```
public interface Iterator<E>
{
    boolean hasNext();
    E next();
    …
}
```

It's a stateful object that lets you **iterate through a data structure**.

A bit iterator

Suppose we want to do the following:

On each iteration, get the **next most significant bit**, starting initially with the **least significant bit**.

`BIterator` to the rescue.

Recap & Next Class

Today:

Iterators

Number representations

Next class:

Tree ADT