CS61B Lecture #18

Today:

- Asymptotic complexity (from last time)
- Overview of standard Java Collections classes.
  - Iterators, ListIterators
  - Containers and maps in the abstract
  - Views

Readings for Today: *Data Structures*, Chapter 2.

Readings for next Topic: *Data Structures*, Chapter 3.

Some Intuition on Meaning of Growth

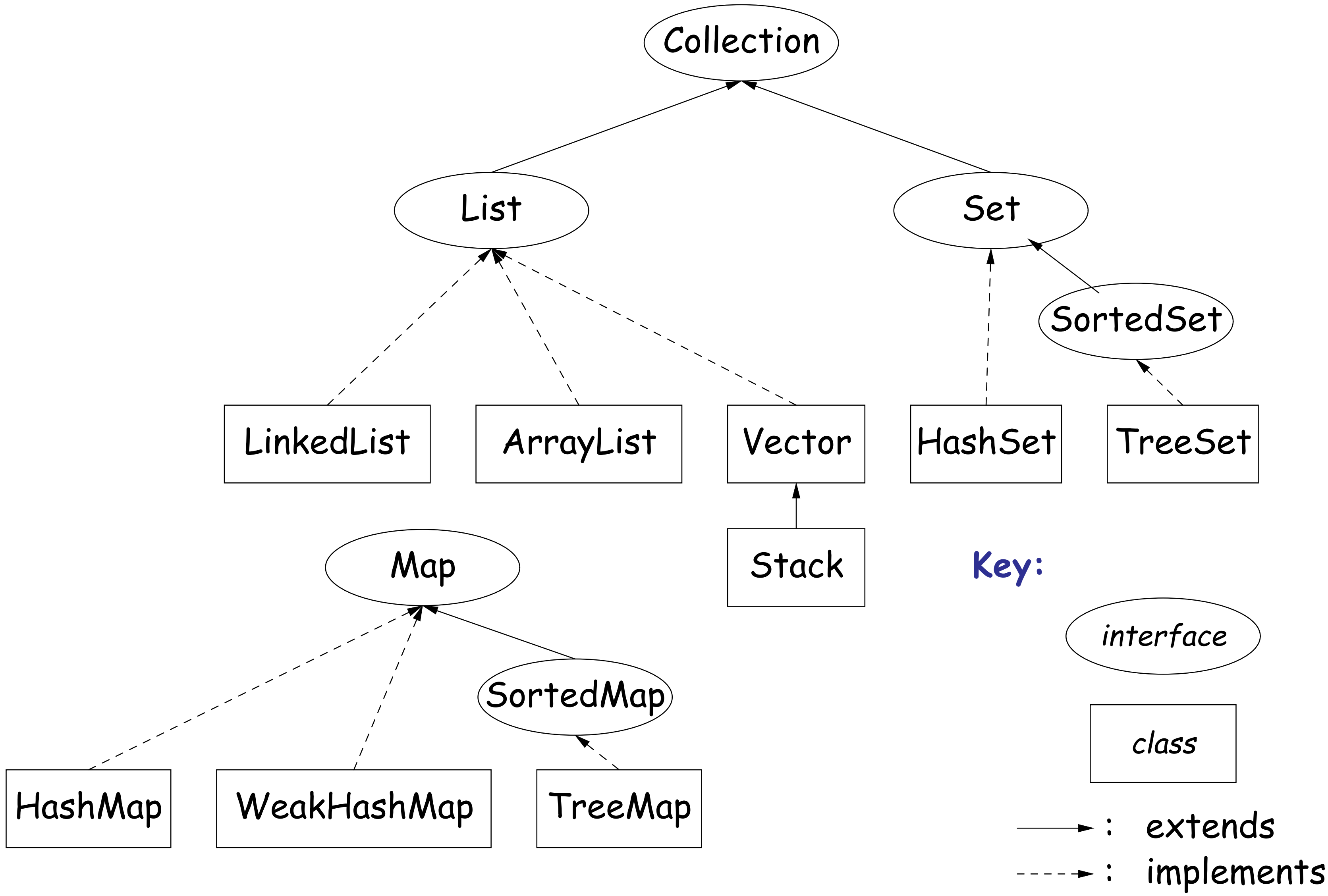
- How big a problem can you solve in a *given* time?
- In the following table, left column shows time in microseconds to solve a *given* problem as a function of problem size N.
- Entries show the *size of problem* that can be solved in a second, hour, month (31 days), and century, for various relationships between time required and problem size.
- $N =$ problem size

Time (μsec) for problem size N	**Max N Possible in** 1 second	1 hour	1 month	1 century
$\lg N$	10^{300000}	$10^{1000000000}$	$10^{8 \cdot 10^{11}}$	$10^{9 \cdot 10^{14}}$
N	10^6	$3.6 \cdot 10^9$	$2.7 \cdot 10^{12}$	$3.2 \cdot 10^{15}$
$N \lg N$	63000	$1.3 \cdot 10^8$	$7.4 \cdot 10^{10}$	$6.9 \cdot 10^{13}$
N^2	1000	60000	$1.6 \cdot 10^6$	$5.6 \cdot 10^7$
N^3	100	1500	14000	150000
2^N	20	32	41	51

New Topic: Data Types in the Abstract

- Most of the time, should *not* worry about implementation of data structures, search, etc.
- What they do for us—their specification—is important.
- Java has several standard types (in `java.util`) to represent collections of objects
  - Six interfaces:
    - `Collection`: General collections of items.
    - `List`: Indexed sequences with duplication
    - `Set`, `SortedSet`: Collections without duplication
    - `Map`, `SortedMap`: Dictionaries (key $\mapsto$ value)
  - Concrete classes that provide actual instances: `LinkedList`, `ArrayList`, `HashSet`, `TreeSet`.
  - To make change easier, purists would use the concrete types only for **new**, interfaces for parameter types, local variables.

Collection Structures in java.util



The Collection Interface

- Collection interface. Main functions promised:
  - Membership tests: `contains` ($\in$), `containsAll` ($\subseteq$)
  - Other queries: `size`, `isEmpty`
  - Retrieval: `iterator`, `toArray`
  - *Optional* modifiers: `add`, `addAll`, `clear`, `remove`, `removeAll` (set difference), `retainAll` (intersect)
- Design point (a side trip): Optional operations may throw

  `UnsupportedOperationException`

- An alternative design would have separate interfaces:

```
interface Collection { contains, containsAll, size, iterator, ... }
interface Expandable { add, addAll }
interface Shrinkable { remove, removeAll, difference, ... }
interface ModifiableCollection
   extends Collection, Expandable, Shrinkable { }
...
```

You'd soon have lots of interfaces. Perhaps that's why they didn't do it that way.)

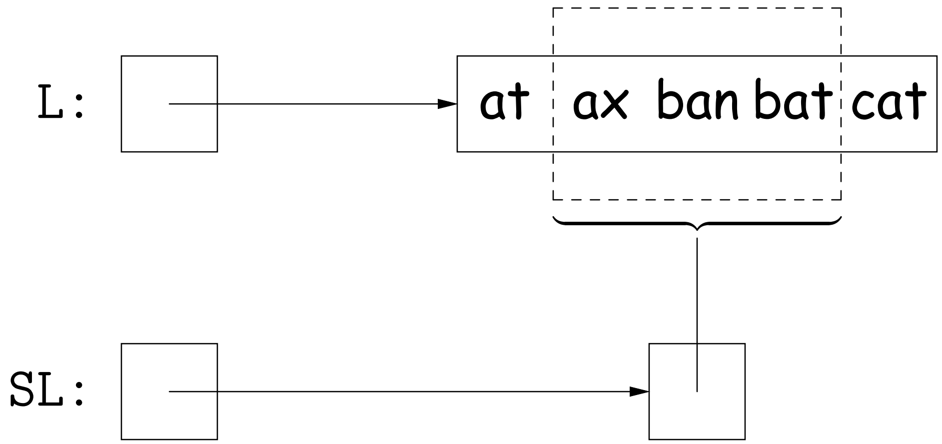
The List Interface

- Extends `Collection`
- Intended to represent *indexed sequences* (generalized arrays)
- Adds new methods to those of `Collection`:
  - Membership tests: `indexOf`, `lastIndexOf`.
  - Retrieval: `get(`i`)`, `listIterator()`, `sublist(`B, E`)`.
  - Modifiers: `add` and `addAll` with additional index to say *where* to add. Likewise for removal operations. `set` operation to go with `get`.
- Type `ListIterator<Item>` extends `Iterator<Item>`:
  - Adds `previous` and `hasPrevious`.
  - `add`, `remove`, and `set` allow one to iterate through a list, inserting, removing, or changing as you go.
  - **Important Question:** What advantage is there to saying `List L` rather than `LinkedList L` or `ArrayList L`?

Views

New Concept: *A view* is an alternative presentation of (interface to) an existing object.

- For example, the `sublist` method is supposed to yield a "view of" part of an existing list:




```
List<String> L = new ArrayList<String>();
L.add ("at"); L.add("ax"); ...
List<String> SL = L.sublist (1,4);
```

- Example: after `L.set(2, "bag")`, value of `SL.get(1)` is `"bag"`, and after `SL.set(1,"bad")`, value of `L.get(2)` is `"bad"`.

- Example: after `SL.clear()`, `L` will contain only `"at"` and `"cat"`.

- Small challenge: "How do they *do* that?!"

Maps

- A `Map` is a kind of “modifiable function:”

```
package java.util;
public interface Map<Key,Value> {
  Value get (Object key);                 // Value at KEY.
  Object put (Key key, Value value);      // Set get(KEY) -> VALUE
  ...
}
------------------------------------------------------
Map<String,String> f = new TreeMap<String,String> ();
f.put ("Paul", "George"); f.put ("George", "Martin");
f.put ("Dana", "John");
// Now f.get ("Paul").equals ("George")
//     f.get ("Dana").equals ("John")
//     f.get ("Tom") == null
```

Map Views

```
public interface Map<Key,Value> { // Continuation
           /* VIEWS */
  /** The set of all keys. */
  Set<Key> keySet ();
  /** The multiset of all values */
  Collection<Value> values ();
  /** The set of all (key, value) pairs */
  Set<Map.Entry<Key,Value>> entrySet ();
}
```

Using example from previous slide:

```
for (Iterator<String> i = f.keySet ().iterator (); i.hasNext ();)
   i.next ()  ===>  Dana, George, Paul
// or, just:
for (String name : f.keySet ())
   name  ===>  Dana, George, Paul

for (String parent : f.values ())
   parent ===>  John, Martin, George
for (Map.Entry<String,String> pair : f.entrySet ())
   pair  ===>  (Dana,John), (George,Martin), (Paul,George)
f.keySet ().remove ("Dana");   // Now f.get("Dana") == null
```