Sets, Maps, Bit Sets

Section 2.3

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C/C++ pointers

For those unfamiliar with *pointers* . . .

```
int i;    // integer
int *p;   // integer pointer

p = &i;   // & is the reference operator
*p = 74;  // * is the dereference operator

cout << i << endl;  // prints the value 74
```

Binky Pointer Fun Video: http://cslibrary.stanford.edu/104/

Pointers to *objects* use the -> operator

- In C++, `foo->bar` is equivalent to `(*foo).bar`
- Since Java has no pointers, it simply uses dot

Reality Check

Pointers make it possible to allocate `new` memory!

Stack vs heap allocation

```
int main()
{
    string s1("Hello");  // constructor
    cout << s1.length();
}
```

- Local variables are allocated *on the stack*
- When functions return, objects are destructed

```
int main()  // notice use of new and ->
{
    string *s1 = new string("Hello");
    cout << s1->length();
}
```

- Pointers are simply integers (allocated on the stack)
- The objects they point to are allocated *in the heap*

C++ iterators

Iterators are a generalization of pointers

- They must implement * (dereference)
- They must implement ++ (i.e., get next)

```
// example from last week
vector<int>::iterator iter;
for (iter = v.begin(); iter != v.end(); iter++)
    cout << *iter << endl;
```

SPOILER ALERT!

- Not all data structures are linear (like arrays)
- But you don't have to worry about that issue

Non-Linear Data Structures

When making an array for every possible item would be insane.

What's a set? (C++)

Unordered collection of objects

- Set of vowels $V = \{a, e, i, o, u\}$

Hint for UVa 11849: Compact Discs

```
set<int> nums;
nums.insert(74);
nums.insert(78);
nums.insert(82);
nums.insert(74);  // no new element inserted

set<int>::iterator iter;
iter = nums.find(82);
// find returns nums.end() if not found
```

http://www.cplusplus.com/reference/set/set/

What's a set? (Java)

Unordered collection of objects

- Set of vowels $V = \{a, e, i, o, u\}$

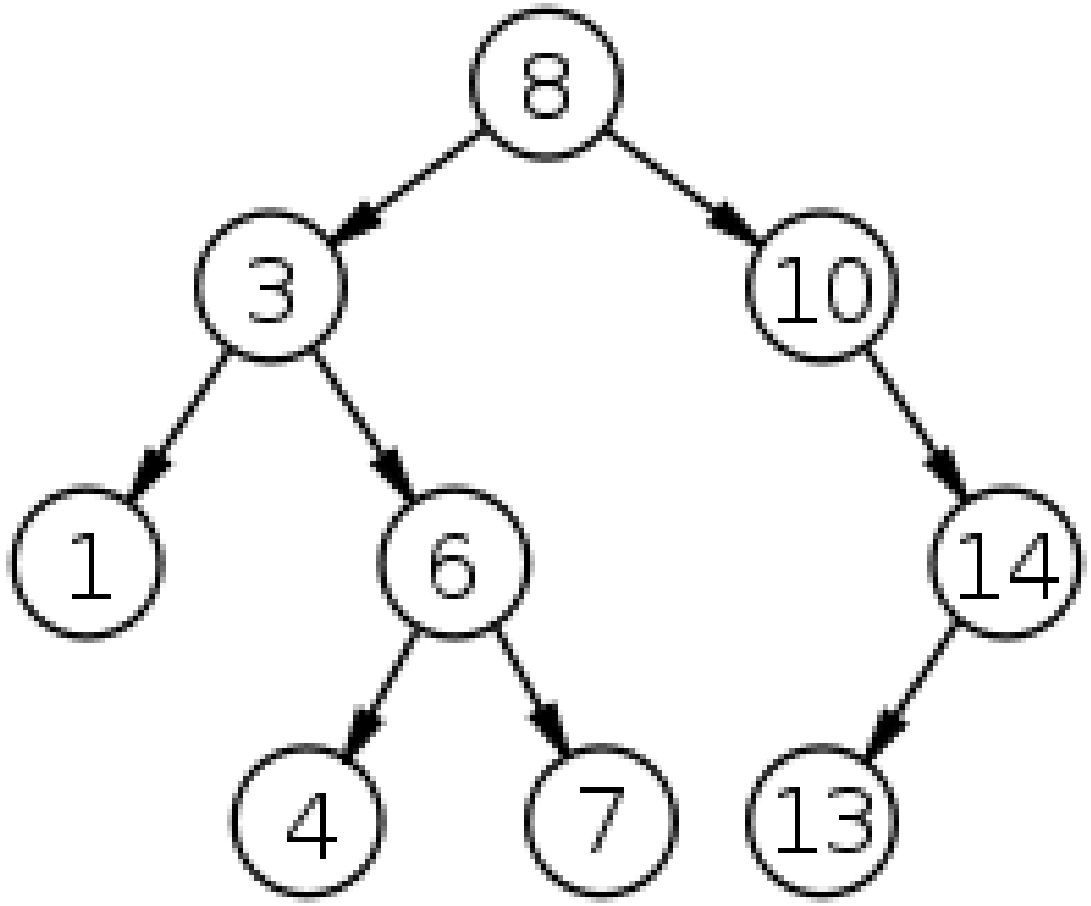
Hint for UVa 11849: Compact Discs

```
// must use reference types like Integer
Set<Integer> nums = new HashSet<Integer>();

nums.add(74);
nums.add(78);
nums.add(82);
nums.add(74);  // no new element inserted

nums.contains(82);  // returns true or false
```

https://docs.oracle.com/javase/7/docs/api/java/util/Set.html

Binary search tree

Internal data structure for STL `set`, `map` (Java `TreeSet`, `TreeMap`)



What's a map?

Data structure of (key, value) pairs

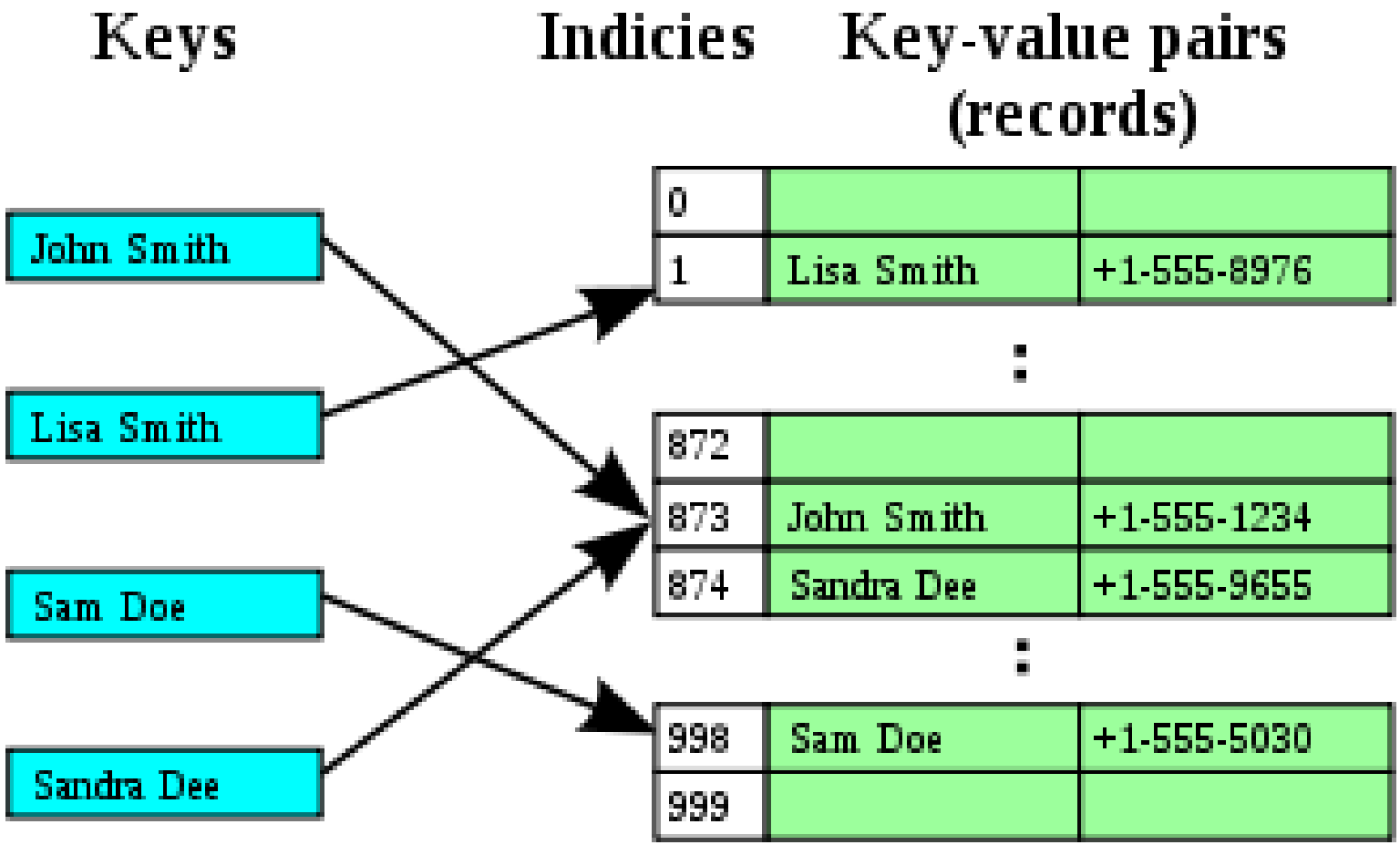
- No two entries have the same key
- Allows you to store additional data
- Implemented with trees or hashing

Applications

- Dictionaries
- Counting problems
- Lots of others!

Hash table

Internal data structure for STL `unordered_map` (Java `HashMap`)



Maps in Java (ugly)

```
import java.util.Iterator;
import java.util.Map;
import java.util.TreeMap;

// map each word to its anagram
TreeMap<String, String> map =
        new TreeMap<String, String>();
map.put(word, anag);

// output results in sorted order
Iterator<Map.Entry<String, String>> iter =
        map.entrySet().iterator();
while (iter.hasNext()) {
    Map.Entry<String, String> entry = iter.next();
    System.out.println(entry.getKey() + ": "
            + entry.getValue());
}
```

Maps in C++ (easier)

```
#include <map>
using namespace std;

// map course names to numbers
map<string, int> courses;
courses["Databases"] = 474;
courses["Networking"] = 462;
courses["Friday Fun"] = 280;

// output results
map<string, int>::iterator ii;
for (ii = courses.begin(); ii != courses.end(); ii++)
{
    cout << ii->first << ": " << ii->second << endl;
}
```

Other C++ tips

Use `typedef` to create aliases

```
typedef map<string, int> map_si;
typedef map<string, int>::const_iterator itr_si;

int main()  // Hint for UVa 10226: Hardwood Species
{
    map_si trees;
    itr_si itr;
}
```

Use `const` whenever possible

```
for (itr = trees.begin(); itr != trees.end(); itr++)
{
    const char* name = itr->first.c_str();
    double percent = 100.0 * itr->second / total;
    printf("%s %.4f\n", name, percent);
}
```

Bit sets

Sometimes linear is better :-)

- Array of 1,000,000 booleans
- Building a tree is too slow
- Trick: use binary numbers!

Hint for UVa 11926: Multitasking

```
bitset<10> bs;
bs.set(1);
cout << bs << endl;  // prints 0000000010
bs.reset(1);
cout << bs << endl;  // prints 0000000000
```

Hint for UVa 11933: Splitting Numbers

```
bitset<32> bs(74);
cout << bs << endl;  // 00000000000000000000000001001010
cout << bs.to_ulong();
```