Const Correctness

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Administrivia

Assignment 3 goes out on Thursday

Administrivia

Apply to Section Lead by Next Thursday

Why Const?

"I still sometimes come across programmers who think const isn't worth the trouble. "Aw, const is a pain to write everywhere," I've heard some complain. "If I use it in one place, I have to use it all the time. And anyway, other people skip it, and their programs work fine. Some of the libraries that I use aren't const-correct either. Is const worth it?"

We could imagine a similar scene, this time at a rifle range: "Aw, this gun's safety is a pain to set all the time. And anyway, some other people don't use it either, and some of them haven't shot their own feet off..."

Safety-incorrect riflemen are not long for this world. Nor are const-incorrect programmers, carpenters who don't have time for hard-hats, and electricians who don't have time to identify the live wire. **There is no excuse for ignoring the safety mechanisms provided with a product, and there is particularly no excuse for programmers too lazy to write const-correct code**."

- Herb Sutter, generally cool dude

Why Const?

Instead of asking why you think **const** is important, I want to start with a different question.

Why don't we use global variables?

Why Const?

- "Global variables can be read or modified by any part of the program, making it difficult to remember or reason about every possible use"
- "A global variable can be get or set by any part of the program, and any rules regarding its use can be easily broken or forgotten"

Why Const?

- "Non-const variables can be read or modified by any part of the function, making it difficult to remember or reason about every possible use"
- "A non-const variable can be get or set by any part of the function, and any rules regarding its use can be easily broken or forgotten"

Why Const?

Find the bug in this code:

```
void f(int x, int y) {
  if ((x==2 && y==3)||(x==1))
     cout << 'a' << endl;
  if ((y==x-1)&&(x==-1||y=-1))
     cout << 'b' << endl;
  if ((x==3)&&(y==2*x))
    cout << 'c' << endl;
}
```

Why Const?

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void f(int x, int y) {
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     cout << 'b' << endl;
  if ((x==3)&&(y==2*x))
    cout << 'c' << endl;
}
```

Why Const?

Find the bug in this code:

```
void f(const int x, const int y) {
  if ((x==2 && y==3)||(x==1))
     cout << 'a' << endl;
  if ((y==x-1)&&((x==-1)||(y=-1)))
     cout << 'b' << endl;
  if ((x==3)&&(y==2*x))
    cout << 'c' << endl;
}
```

Why Const?

The compiler finds the bug for us!

```
test.cpp: In function 'void f(int, int)':
test.cpp:7:31: error: assignment of read-only
parameter 'y'
```

Why Const?

That's a fairly basic use case though, is that really all that const is good for?

The const Model

```
Planet earth;
```

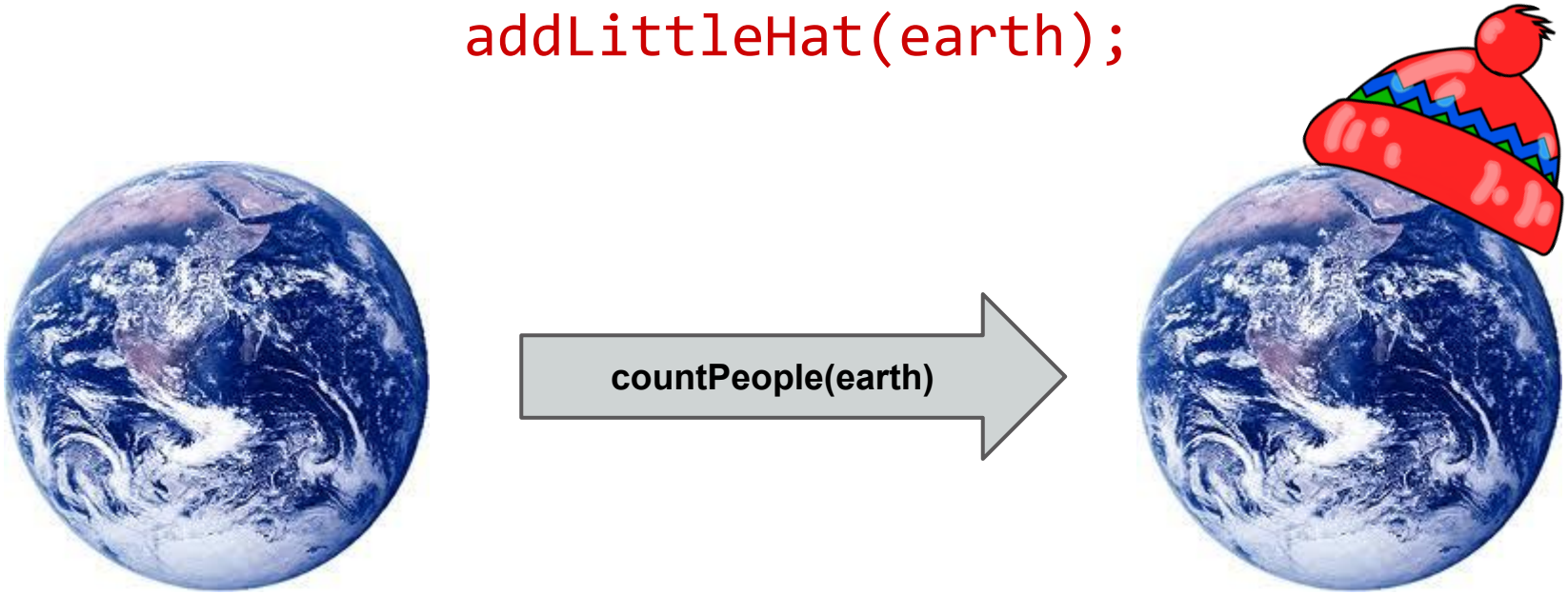
The const Model

```
long int countPeople(Planet& p);

long int population = countPeople(earth);
```

The const Model

```
addLittleHat(earth);
```



The const Model

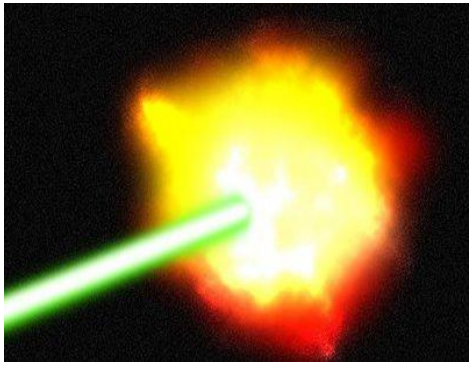
```
marsify(earth);
```

countPeople(earth)

The const Model

```
deathStar(earth);
```

countPeople(earth)



Why Const?

How did this happen?

The const Model

```
long int countPopulation(Planet& p) {
   // I don't like people not wearing hats
  addLittleHat(p);

  // Mars-like planets are easier to deal with
  marsify(p);

  // Optimization: destroy planet
  // This makes population counting O(1)
  deathStar(p);
  return 0;
}
```

The const model

What would happen if I made that a const method?

The const Model

```
long int countPopulation(const Planet& p) {
    // I don't like people not wearing hats
  addLittleHat(p);

  // Mars-like planets are easier to deal with
  marsify(p);

  // Optimization: destroy planet
  // This makes people counting O(1)
  deathStar(p);
  return 0;
}
```

The const Model

```
test.cpp: In function ‘long int countPopulation(const Planet&)’:

test.cpp:9:21: error: invalid initialization of reference of type
‘Planet&’ from expression of type ‘const Planet’
test.cpp:3:6: error: in passing argument 1 of ‘void addLittleHat
(Planet&)’

test.cpp:12:12: error: invalid initialization of reference of type
‘Planet&’ from expression of type ‘const Planet’
test.cpp:4:6: error: in passing argument 1 of ‘void marsify(Planet&)’

test.cpp:16:14: error: invalid initialization of reference of type
‘Planet&’ from expression of type ‘const Planet’
test.cpp:5:6: error: in passing argument 1 of ‘void deathStar(Planet&)’
```

The const Model

const allows us to reason about whether a variable will be changed.

The const Model

```
void f(int& x) {
   // The value of x here
   aConstMethod(x);
   anotherConstMethod(x);
   // Is the same value of x here
}
```

The const Model

```
void f(const int& x) {
   // Anything whatsoever
}
void g() {
   int x = 2;
   f(x);
   // x is still equal to two
}
```

const and Classes

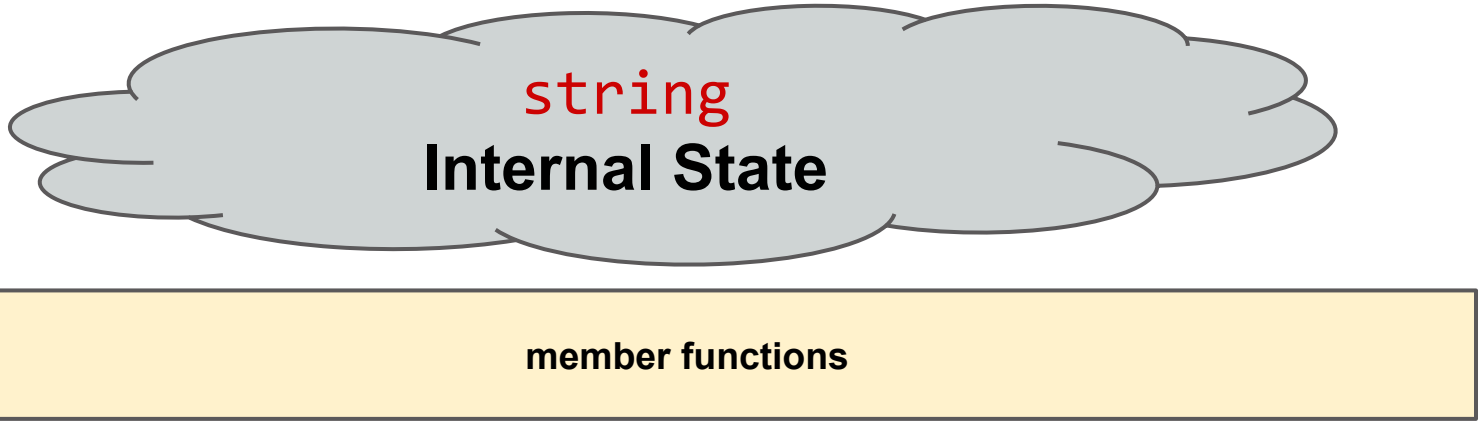
This is great for things like `int`s, but how does `const` interact with classes?

How do we define `const` member functions?

const and Classes

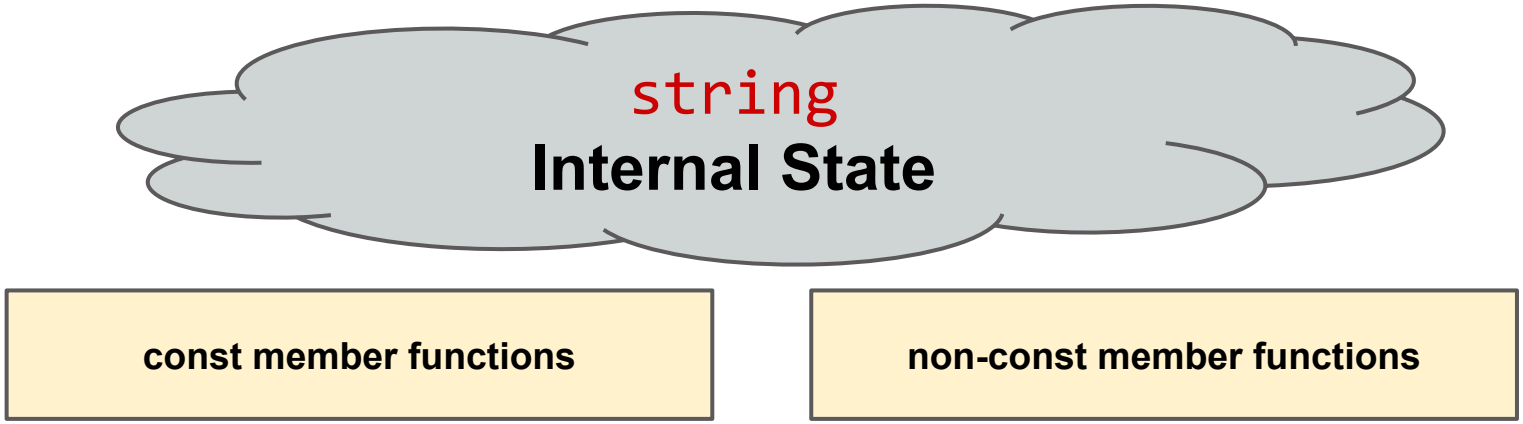
Let's have this cloud represent the member variables of a certain string

const and Classes



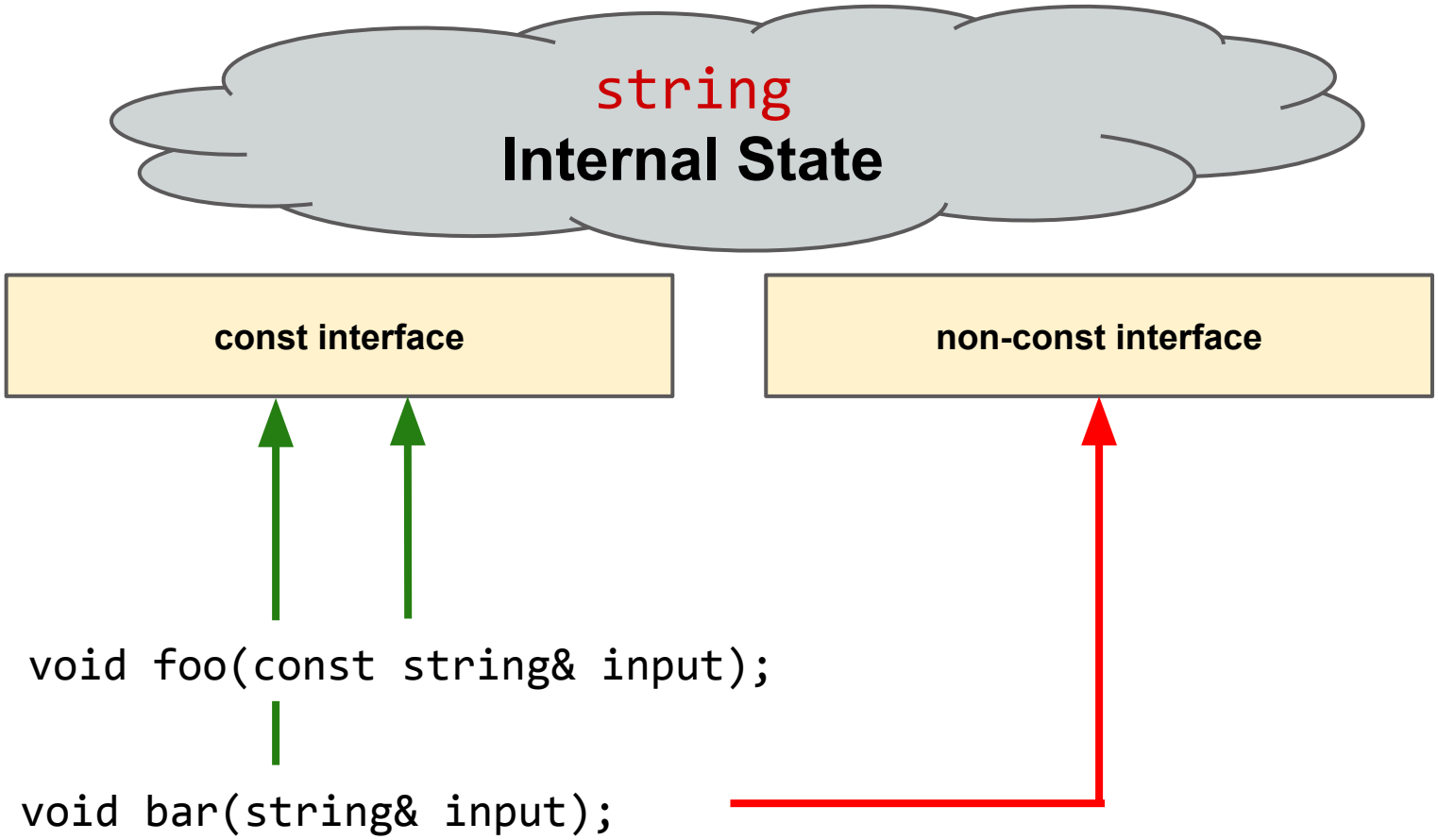
Previously, we thought that you just used member functions to interact with an instance of an object

const and Classes



Now we see that there are both const and non-const member functions, and const objects can't use non-const member functions

const and Classes



The const Model

```
// Defining const member functions
struct Planet {
  int countPopulation() const;
  void deathStar();
};
int Plant::countPopulation() const {
  return 42; // seems about right
}
void Planet::deathStar() {
  cout << "BOOM" << endl;
}
```

The const Model

```
// using const member functions
struct Planet {
  int countPopulation() const;
  void deathStar();
};
void evil(const Planet &p) {
  // OK: countPopulation is const
   cout << p.countPopulation() << endl;
  // NOT OK: deathStar isn't const
  p.deathStar();
}
```

Adding Const to Vector

Let's go through as much of const as we can on vector

Removing Const

- Sometimes it is necessary to remove const
  - think VERY CAREFULLY before doing so
- **const casting** can be used to remove the const
  - again… use this sparingly and think VERY CAREFULLY before doing so

```
const_cast<Type>(a const value);
```

A Const Pointer

- Using pointers with const is a little tricky
  - When in doubt, read right to left

```
//constant pointer to a non-constant Widget
Widget* const p;

//non-constant pointer to a constant Widget
const Widget* p; Widget const* p;

//constant pointer to a constant Widget
const Widget* const p; Widget const* const p;
```

Const Iterators

- Remember that iterators act like pointers
- `const vector<int>::iterator itr` however, acts like `int* const itr`
- To make an iterator read only, define a new const_iterator

Const Iterators

```
const vector<int>::iterator itr = v.begin();
*itr = 5; //OK! changing what itr points to
++itr; //BAD! can’t modify itr

vector<int>::const_iterator itr = v.begin();
*itr = 5; //BAD! can’t change value of itr
++itr; //OK! changing v
int value = *itr; //OK! reading from itr
```

Recap

- For the most part, always anything that does not get modified should be marked const
- Pass by const reference is better than pass by value
- Member functions should have both const and non const iterators
- Read right to left to understand pointers
- Please don’t make a method to blow up earth