Recursion review

- Thinking recursion: if I know the solution of the problem of size N-1, can I use that to solve the problem of size N.
- Writing recursive routines:
  - Decide the prototype
    - Can formulate both original and sub-problems
    - Solution to a sub-problem is just one recursive routine call.
  - Base case
  - Recursive case.
- Execution of a recursive routine:
  - Keep calling the recursive routines to solve problems of smaller sizes until the base case is reached. Then from the solutions of smaller problems to construct solutions of larger problems until the original problems is solved.

Recursion review

- Determine a word is a palindrome?

```
bool ispalindrome(string word, int front, int back)
{
…
}
```

- Search if a number is in an array

```
bool search(int A[], int beg, int end, int value)
// return true if value is in A[beg..end]
// false otherwise
```

- The number puzzle …

- Copy constructor and assignment operator

Automatically Generated Functions

- We have learned of two member functions sometimes automatically generated by the compiler
  - Constructor – An empty default (ie. no params) constructor is created if no constructor is defined.
  - Destructor – An empty destructor is created if no destructor is defined.
- Today we will discuss two other sometimes automatically generated member functions
  - Copy Constructor
  - Assignment Operator

Copy Constructor

- A copy constructor IS a constructor and therefore:
  - has the same name as the class
  - has no return type (although, it seems to return a class object when called explicitly)
- Like the conversion constructor, there are situations when the copy constructor is called implicitly. They are:
  - when an object is declared to have the same value as another object

    Example: Fraction f1(1,2);

    Fraction f2 = f1; //new object f2 is initialized as a COPY of f1
  - when an object is passed *by value* into a function
  - when an object is returned *by value* from a function

Copy Constructor Declaration

- Since the purpose of a copy constructor is to initialize a new object to be a copy of another object, it accepts a single object as a parameter
- Format: classname(const classname&)
- The argument is const because the copy constructor should not alter the original (not required)
- The argument MUST be passed by reference.
- Examples
  - Fraction(const Fraction& f)
  - Mixed(const Mixed& m)

Copy Constructor internal

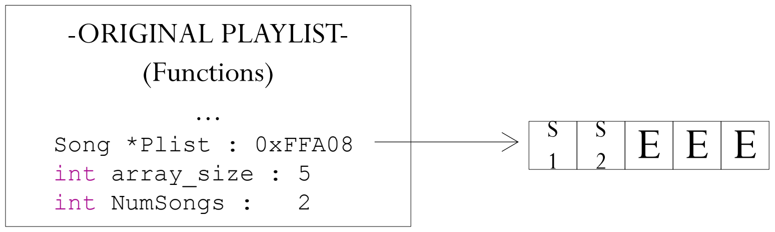
- What should be done in a copy constructor: copy the data member from the parameter to the newly created object.
  - Should be straight-forward – can be produced automatically.

```
Fraction(const Fraction& f) {
    numer = f.numer;
    denom = f. denom;
}
```

  - The automatically generated copy constructor (default copy constructor) does exactly this.
  - This works in many cases, but not always.

Issues with the default: shallow copy

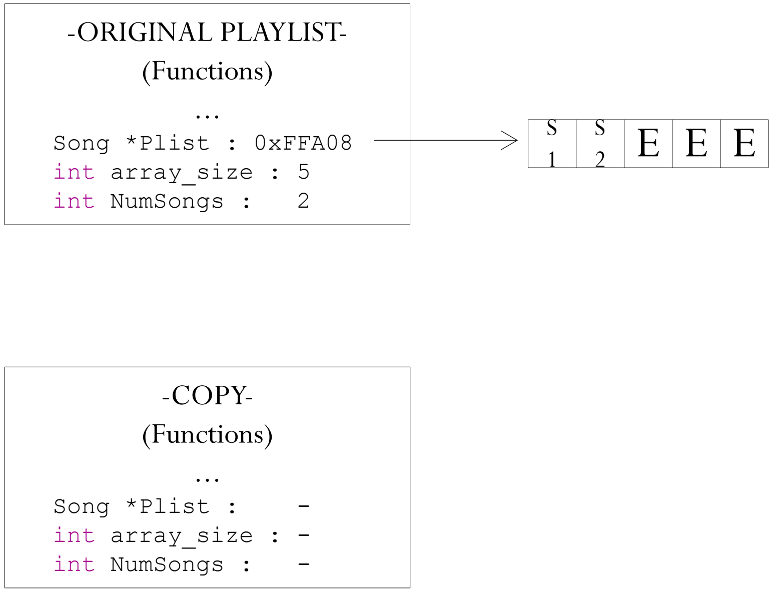
- Suppose we want to copy a playlist object:



- Shallow copy (default) – All member data is copied EXACTLY from the old object into the new one.

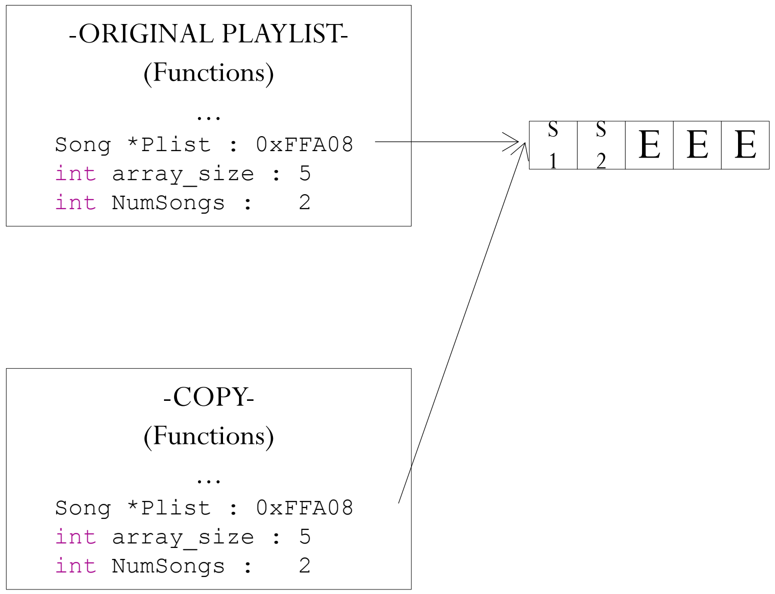
The default: Shallow Copy

- We start in the copy constructor of COPY with the original as a parameter



Shallow Copy

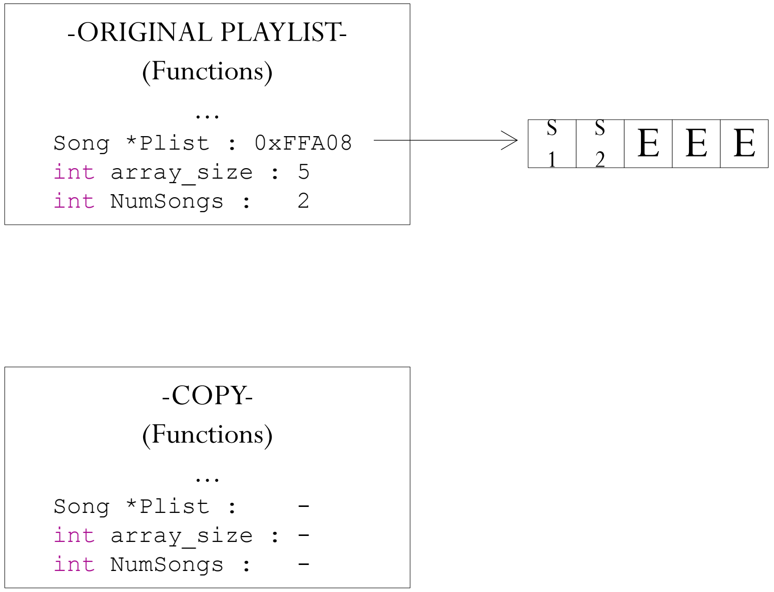
- Set data in copy equal to that of the original... DONE.



What is bad about this: the new object shares the Plist with the old object
The copy is not a real copy, which should produce two independent copies of the object. Hence, the name "shallow copy"

Deep Copy – must be implemented as a customized copy constructor

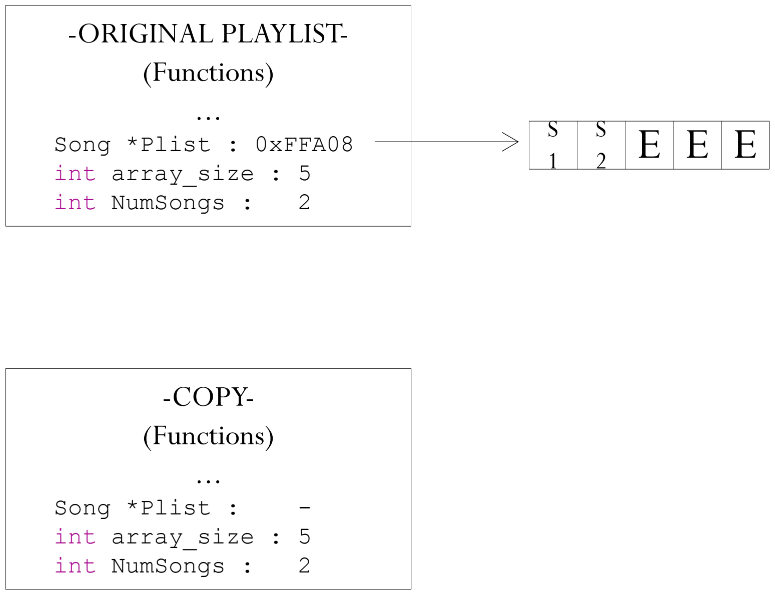
- We start in the copy constructor of COPY with the original as a parameter



Deep copy – New dynamic memory is created for pointers

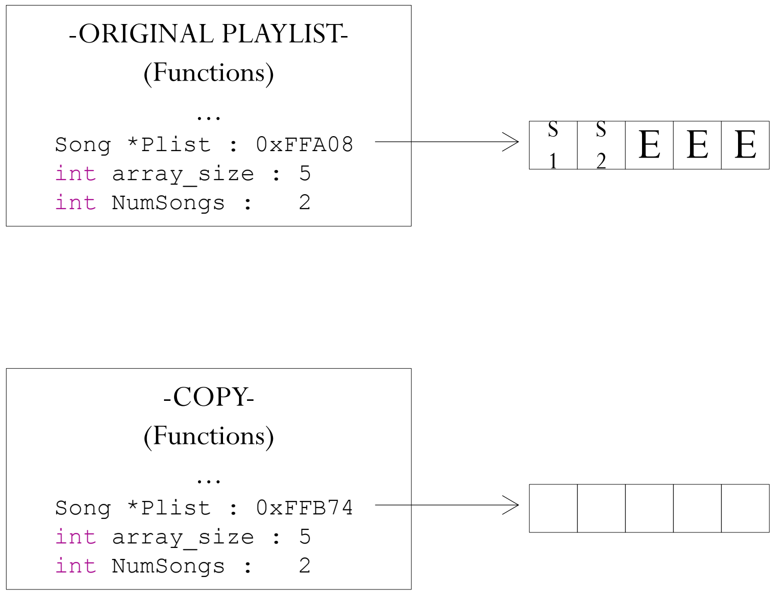
Deep Copy – customized copy constructor

- Set NON-POINTER data in the copy equal to the original



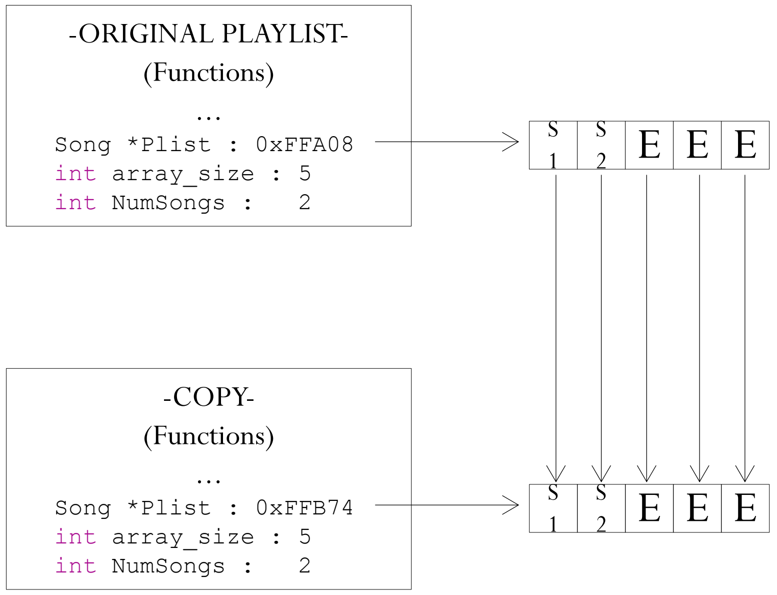
Deep Copy – customized copy constructor

- Allocate new memory for data pointer points to.



Deep Copy

- Copy data from old dynamic memory to new... DONE.



Assignment operator

- The assignment operator (=) is called when one object is assigned to another
- The assignment operator is similar to the copy constructor, but there are some key differences
  - The assignment operator is a normal member function not a constructor, this means 2 objects already exist and have been initialized
  - The assignment operator returns the value it was assigned (allows cascading calls)
    - Fraction f1(1,2),f2,f3,f4;
    - f4 = f3 = (f2 = f1);
    - f4 = (f3 = (f2))
    - (f4 = (f3))
    - (f4)

Assignment operator

- Format: classname& operator=(const classname&);
- Ex. Fraction lhs(1,2), rhs(2,5);
-         lhs = rhs;
- lhs is the calling object, rhs is the parameter, the assignment function alters lhs to be a copy of rhs and returns a reference to lhs.
- If lhs is the calling object, how can we return a reference to it?

The *this* pointer

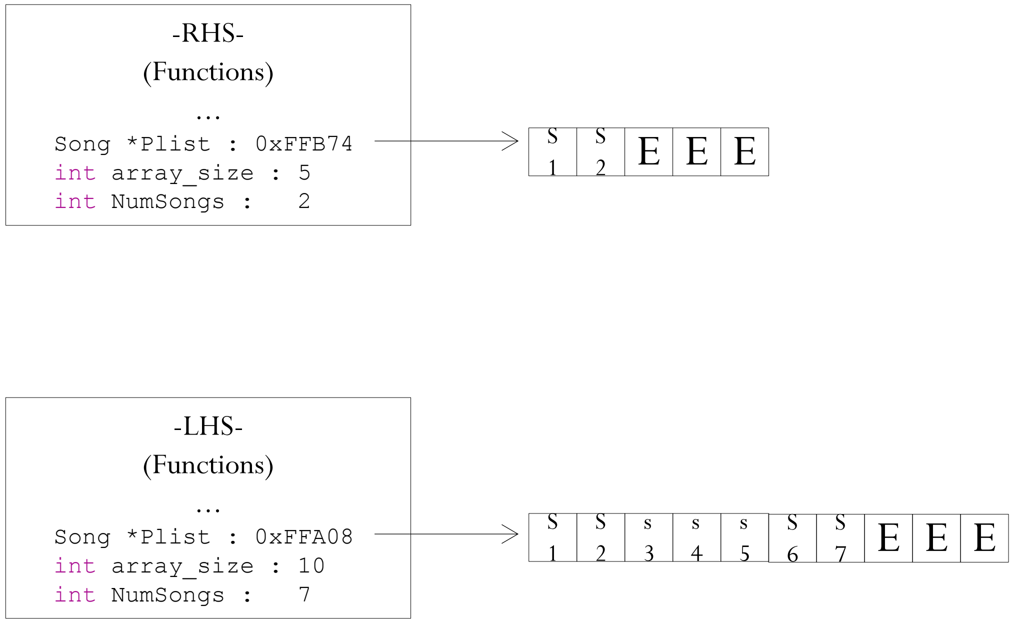
- Inside every object is a pointer named 'this'
- It's like having 'classname *this;' in the member data of an object
- The 'this' pointer is set to point to the object itself
- You can actually call another member function with the statement this->memberFunction()
- We can use the this pointer to return a reference to the object itself in the assignment operator
  - Should we return this or *this ? (this pointer or whats at this pointer?)

Deep Copy (Assignment)

- Suppose we are assigning playlist LHS to RHS (LHS=RHS;)
- The automatically generated copy constructor performs a shallow copy
- Lets see what we would have to do in order to do an overload of the assignment operator that performs a deep copy

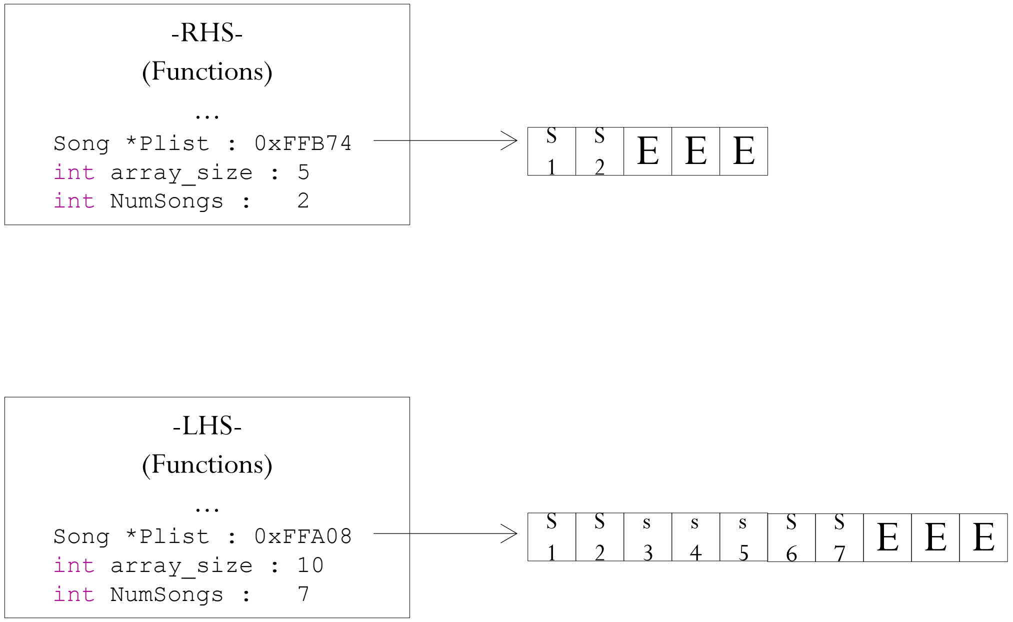
Deep Copy (Assignment)

- LHS is the calling object and already has its own member data that we want to match RHS



Deep Copy (Assignment)

- Since LHS's array is the wrong size, we must deallocate it and reallocate the correct size



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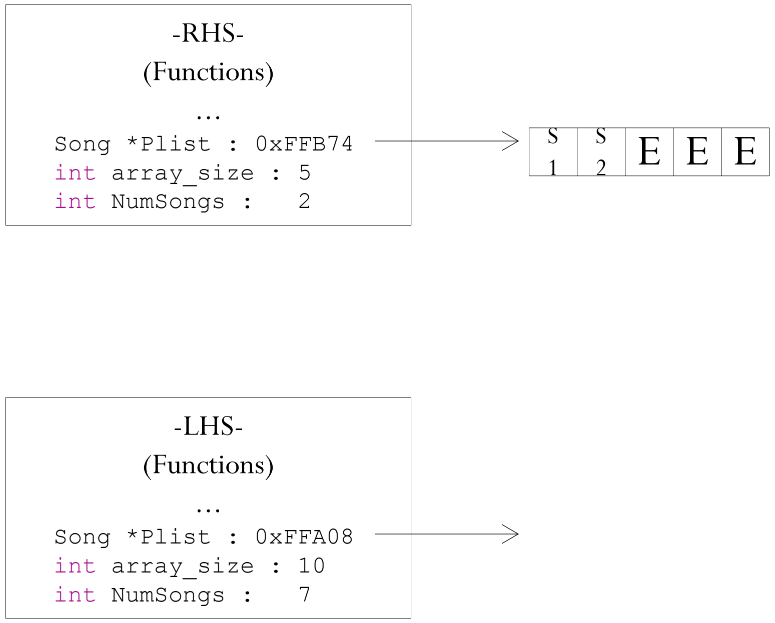

Deep Copy (Assignment)

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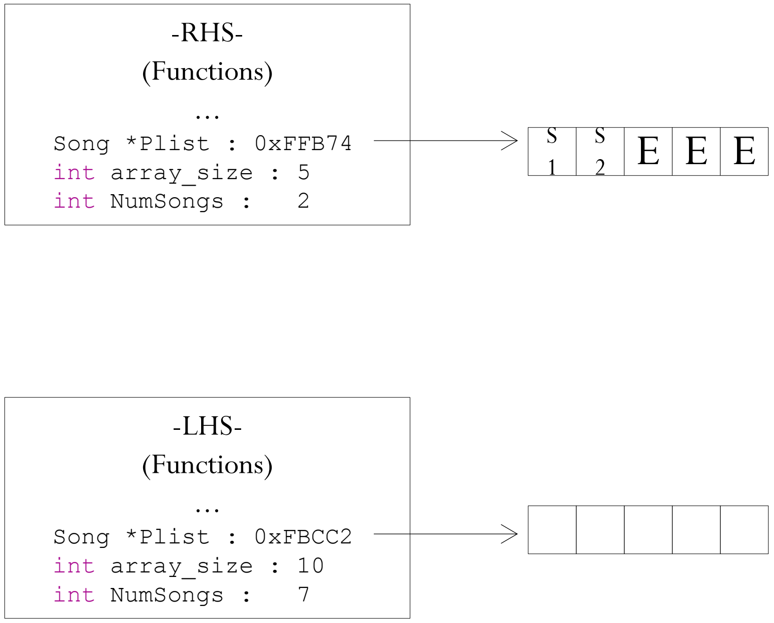
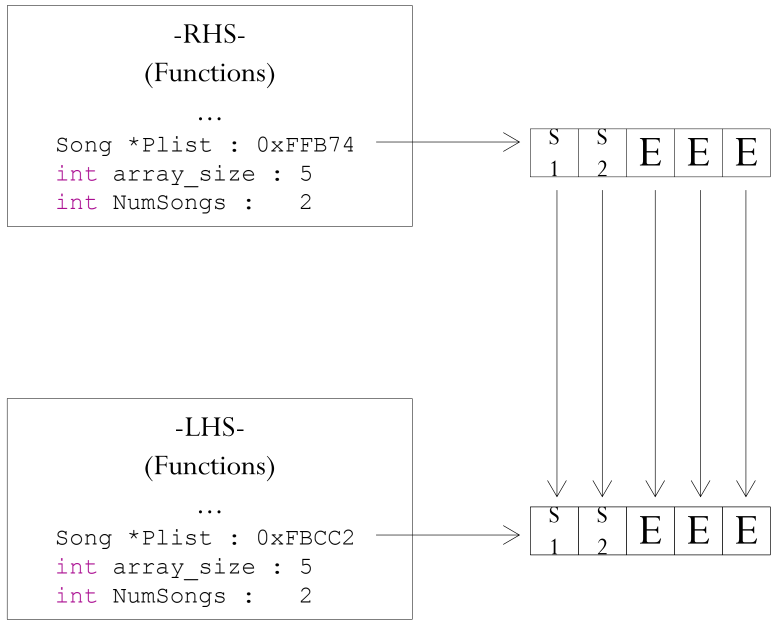


Deep Copy (Assignment)

- We can now copy the elements of RHS to LHS and copy the other member data...DONE.



Everything else

- Assignment operator must always be a member function (can't be friend)
- Assignment operator implementation always ends with: return *this;
- If you define a copy constructor, but no other constructor, an empty default constructor WILL NOT be generated by the compiler