CSCI 262
Data Structures

11 – Array List

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List is an Abstract Data Type

A list contains a sequential* collection of values.

We denote the contents of a list as items, entries, or elements.

There are many different kinds of lists, but in general, we may expect a list to support operations such as:

- Add - add an item to the end
- Insert - add an item between two existing elements
- Get - get the value of an item at the specified index
- Erase - remove an item from the list
- Size - obtain the number of elements in the list

*Note: sequential ≠ sorted!

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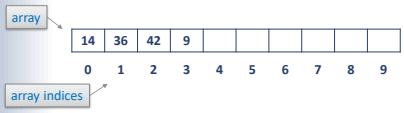
Array List (aka Vector)

Consider a list data structure built on arrays:



We will be using *dynamically allocated* arrays (for reasons which will become clear later)

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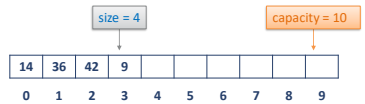
Array List Operations: size

size:

- Returns # of elements in list
- Array size ≠ list size
  - Array size is the *capacity* of the list
  - Need a separate variable to track *size*



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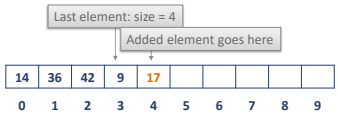
Array List Operations: add

add:

- Add item to end of array
- Increment size



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Array List Operations: Simple add

```
arr[size] = val;
size++;
```

Questions:

- What happens if we forget to increment `size`?
- How are `size` and `capacity` related?
- What happens when we run out of room?

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Encapsulating Array List

We need to:
- Keep array, size, capacity all together
- Maintain *consistent* state

Encapsulation helps us by:
- Keeping data together with functions on data
- Hiding implementation details from user

The primary enabler of encapsulation is the *class*.

A Simple Array List Class

```
class array_list {
public:
        array_list();
        int size();
        int get(int index);
        void set(int index, int val);
        void add(int val);
        void insert(int index, int val);
        void erase(int index);
        int& operator[](int index);
private:
        int*  _arr;
        int   _size;
        int   _capacity;
};
```

Declarations of member functions implementing the major operations (and some extra), plus a constructor.

Private variables for our array, and two other bits of state: the array capacity and the list size.

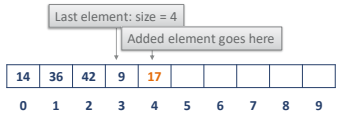
Array List: constructor

Need to setup initial storage, size, capacity:

```
array_list::array_list() {
      _capacity = 1;      // or whatever
      _size = 0;
      _arr = new int[_capacity];
}
```


Array List Operations: add

add:
- Add item to end of array, increment size
- What happens when size == capacity?



Expanding Capacity

Steps:
1. Double* our capacity variable
2. Create a new array using the new capacity
3. Copy everything from old array to new array
4. Delete old array
5. Update the array pointer to point to the new array

*Doubling results in a nice complexity analysis using *amortized* analysis, a technique you will learn later.

Array List Operations: add

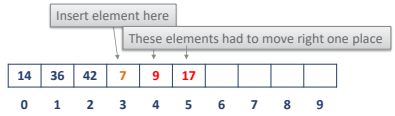
```
void array_list::add(int val) {
      if (_size == _capacity) {
            _capacity = _capacity * 2;
            int* newarr = new int[_capacity];
            for (int j = 0; j < _size; j++)
                  newarr[j] = _arr[j];
            delete[] _arr;
            _arr = newarr;
      }

      _arr[_size] = val;
      _size++;
}
```

Array List Operations: insert

insert:

- Move elements to right
- Put element in place in array



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Array List Operations: insert

```
void array_list::insert(int index, int val) {
	if (_size == _capacity) {
		_capacity = _capacity * 2;
		int* newarr = new int[_capacity];
		for (int j = 0; j < _size; j++)
			newarr[j] = _arr[j];
		delete[] _arr;
		_arr = newarr;
	}

	for (int j = _size; j > index; j--)
		_arr[j] = _arr[j - 1];
	_arr[index] = val;
	_size++;
}
```

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Array List Operations: insert

```
void array_list::insert(int index, int val) {
	if (_size == _capacity) {
		_capacity = _capacity * 2;
		int* newarr = new int[_capacity];
		for (int j = 0; j < _size; j++)
			newarr[j] = _arr[j];
		delete[] _arr;
		_arr = newarr;
	}

	for (int j = _size; j > index; j--)
		_arr[j] = _arr[j - 1];
	_arr[index] = val;
	_size++;
}
```

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Array List Operations: refactored

```
void array_list::_resize() {
	if (_size == _capacity) {
		_capacity = _capacity * 2;
		int* newarr = new int[_capacity];
		for (int j = 0; j < _size; j++)
			newarr[j] = _arr[j];
		delete[] _arr;
		_arr = newarr;
	}
}

void array_list::add(int val) {
	_resize();
	_arr[_size] = val;
	_size++;
}
```

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Array List Operations: refactored (con't)

```
void array_list::insert(int index, int val) {
	_resize();

	for (int j = _size; j > index; j--)
		_arr[j] = _arr[j - 1];
	_arr[index] = val;
	_size++;
}
```

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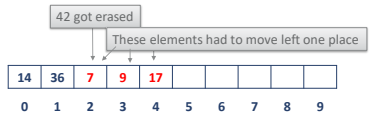
Array List Operations: erase

erase:

- Move elements to left, overwriting erased element



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Array List Operations: erase

```
void array_list::erase(int index) {
      for (int j = index; j < _size - 1; j++)
            _arr[j] = _arr[j + 1];
      _size--;
}
```

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Array List Operations: inlines

```
class array_list {
public:
       array_list();
       int size()                       { return _size; }
       int get(int index)               { return _arr[index]; }
       int set(int index, int val)      { _arr[index] = val; }
       void add(int val);
       void insert(int index, int val);
       void erase(int index);
       int& operator[](int index)       { return _arr[index]; }
private:
       int*  _arr;
       int   _size;
       int   _capacity;
       void  _resize();
};
```

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Up Next

- Friday, October 19
  - Lab 8 – Ancient Algorithms
  - Project 2 - Mazes Due
  - APT 3 Assigned
- Monday, October 22
  - Operator Overloading
  - Reading: Chapter 13
- Wednesday, October 24
  - The “Big 3” (and continuing with ArrayList)

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