Data Structures and Algorithms

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Lecture 02: Arrays

Data Structures

- Prepares the students for (and is a prerequisite for) the more advanced material students will encounter in later courses.
- Cover well-known data structures such as dynamic arrays, linked lists, stacks, queues, tree and graphs.
- Implement data structures in C++

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Need for Data Structures

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Efficiency

- A solution is said to be efficient if it solves the problem within its resource constraints.
    - Space
    - Time

- The *cost* of a solution is the amount of resources that the solution consumes.

Selecting a Data Structure

Select a data structure as follows:

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2. Determine the basic operations that must be supported. Quantify the resource constraints for each operation.
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- Can data be deleted?

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Data Structure Philosophy

- Each data structure has costs and benefits.
- Rarely is one data structure better than another in all situations.
- A data structure requires:
  - space for each data item it stores,
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Arrays

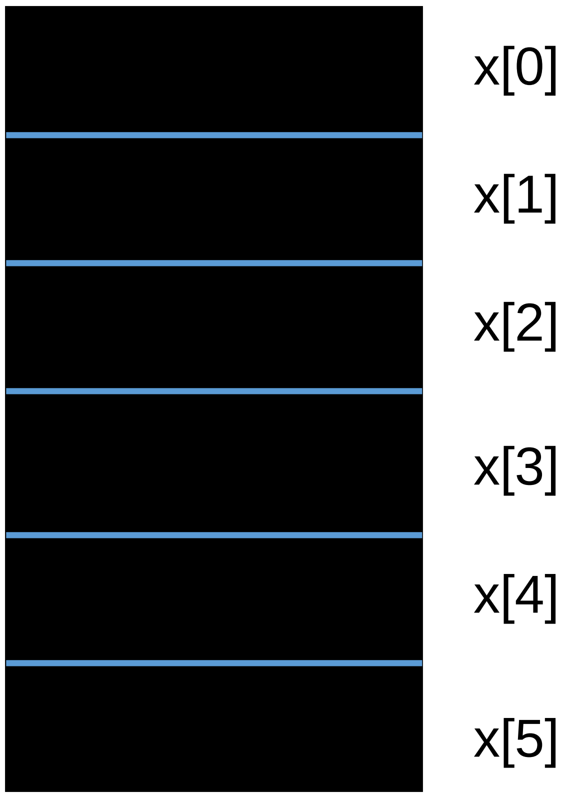
- Array declaration: int x[6];
- Fundamental Data Structure
- An array is collection of cells of the same type.
- The collection has the name ‘x’.
- The cells are numbered with consecutive integers.
- To access a cell, use the array name and an index:

  x[0], x[1], x[2], x[3], x[4], x[5]

Array Layout

Array cells are contiguous in computer memory

The memory can be thought of as an array



What is Array Name?

- ‘x’ is an array name but there is no variable x. ‘x’ is not an *value*.
- For example, if we have the code

```
int a, b;
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  then we can write

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b = 2;
a = b;
a = 5;
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  But we cannot write

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Array Name

- ‘x’ is not an lvalue

```
int x[6];
int n;

x[0] = 5;
x[1] = 2;

x = 3;              // not allowed
x = a + b;          // not allowed
x = &n;             // not allowed
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Dynamic Arrays

- You would like to use an array data structure but you do not know the size of the array at compile time.
- You find out when the program executes that you need an integer array of size n=20.
- Allocate an array using the new operator:

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int* y = new int[20];  // or int* y = new int[n]
y[0] = 10;
y[1] = 15;                    // use is the same
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Dynamic Arrays

- ‘y’ is a lvalue; it is a pointer that holds the address of 20 consecutive cells in memory.
- It can be assigned a value. The new operator returns as address that is stored in y.
- We can write:

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y = &x[0];
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Dynamic Arrays

- We must free the memory we got using the new operator once we are done with the *y* array.

```
delete[ ] y;
```

- We would not do this to the *x* array because we did not use new to create it.

The LIST Data Structure

- The List is among the most generic of data structures.

- Real life:

    a. shopping list,
    b. groceries list,
    c. list of people to invite to dinner
    d. List of presents to get

Lists

- A list is collection of items that are all of the same type (grocery items, integers, names)

- The items, or elements of the list, are stored in some particular order

- It is possible to insert new elements into various positions in the list and remove any element of the list

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Lists

- List is a set of elements in a linear order.
  For example, data values a_1, a_2, a_3, a_4 can be arranged in a list:

  $$(a_3, a_1, a_2, a_4)$$

  In this list, a_3, is the first element, a_1 is the second element, and so on

- The order is important here; this is not just a random collection of elements, it is an *ordered* collection

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List Operations

Useful operations

- createList(): create a new list (presumably empty)
- copy(): set one list to be a copy of another
- clear(); clear a list (remove all elments)
- insert(X, ?): Insert element X at a particular position in the list
- remove(?): Remove element at some position in the list
- get(?): Get element at a given position
- update(X, ?): replace the element at a given position with X
- find(X): determine if the element X is in the list
- length(): return the length of the list.

List Operations

- We need to decide what is meant by “particular position”; we have used “?” for this.

- There are two possibilities:

1. Use the actual index of element: insert after element 3, get element number 6. This approach is taken by arrays
2. Use a “current” marker or pointer to refer to a particular position in the list.

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- We need to decide what is meant by “particular position”; we have used “?” for this.

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2. Use a “current” marker or pointer to refer to a particular position in the list.

List Operations

- If we use the “current” marker, the following four methods would be useful:
  - **start()**: moves to “current” pointer to the very first element.
  - **tail()**: moves to “current” pointer to the very last element.
  - **next**(): move the current position forward one element
  - **back**(): move the current position backward one element