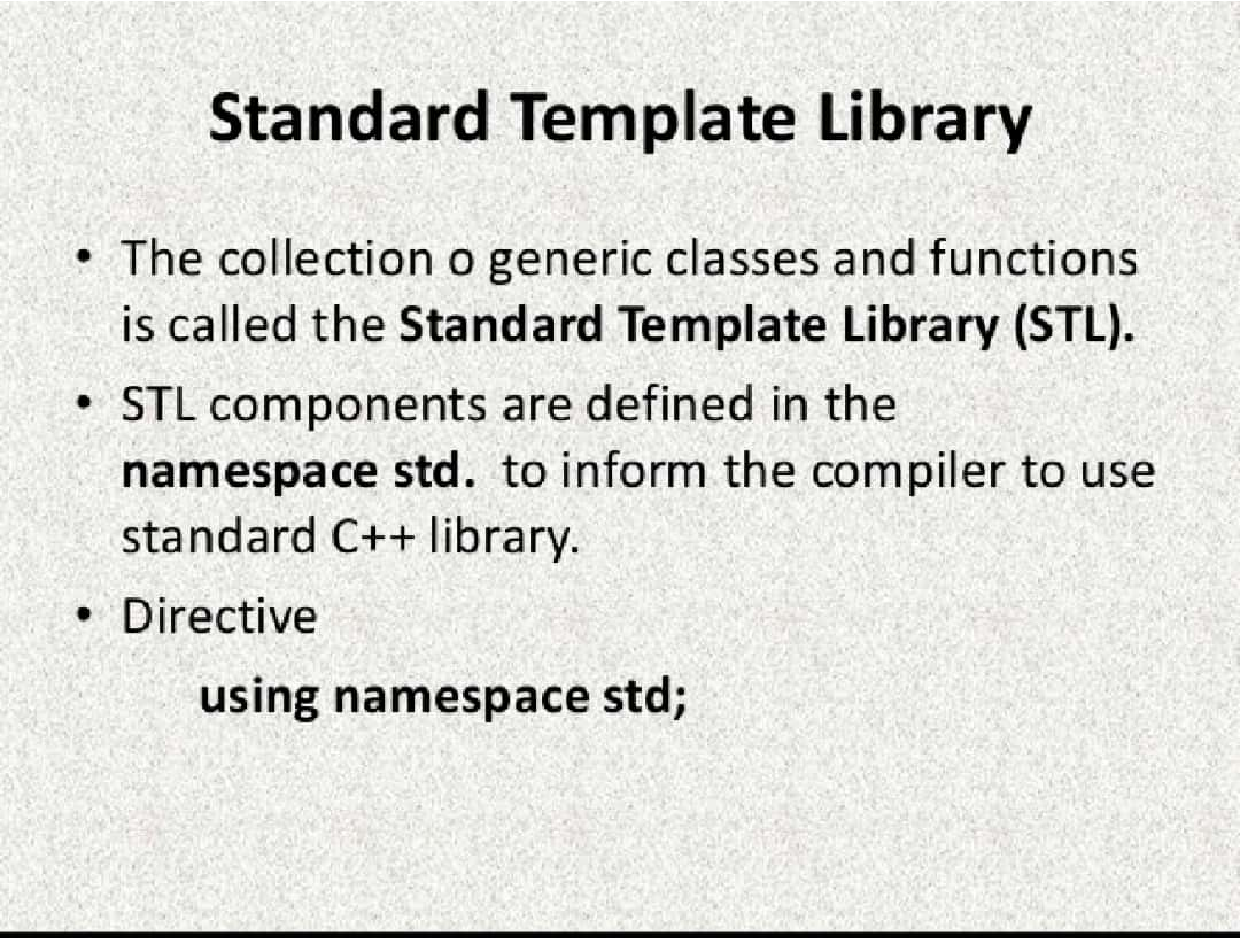

Standard Template Library

- The collection o generic classes and functions is called the **Standard Template Library (STL).**
- STL components are defined in the **namespace std.** to inform the compiler to use standard C++ library.
- Directive

  using namespace std;

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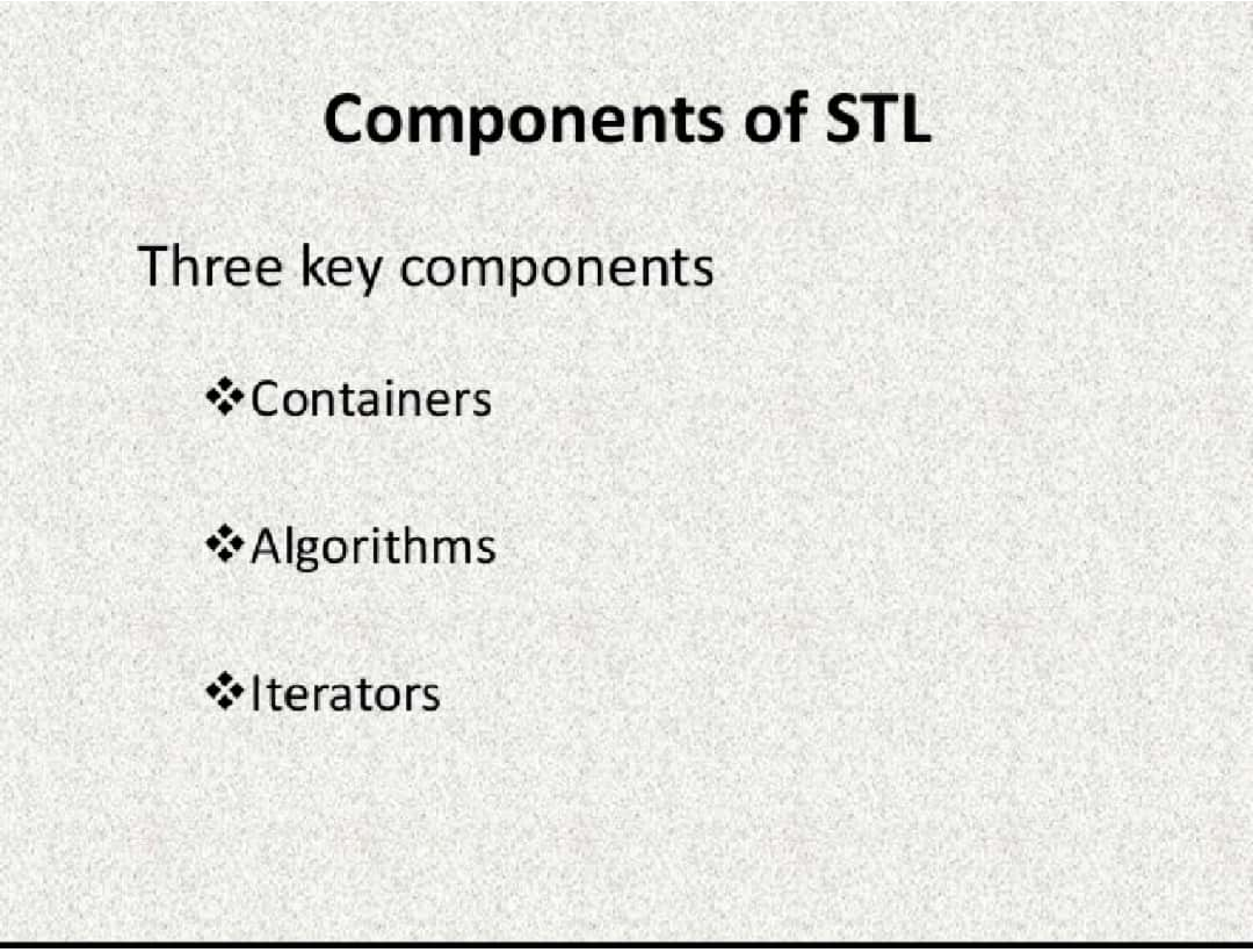

Components of STL

Three key components

- ❖Containers
- ❖Algorithms
- ❖Iterators

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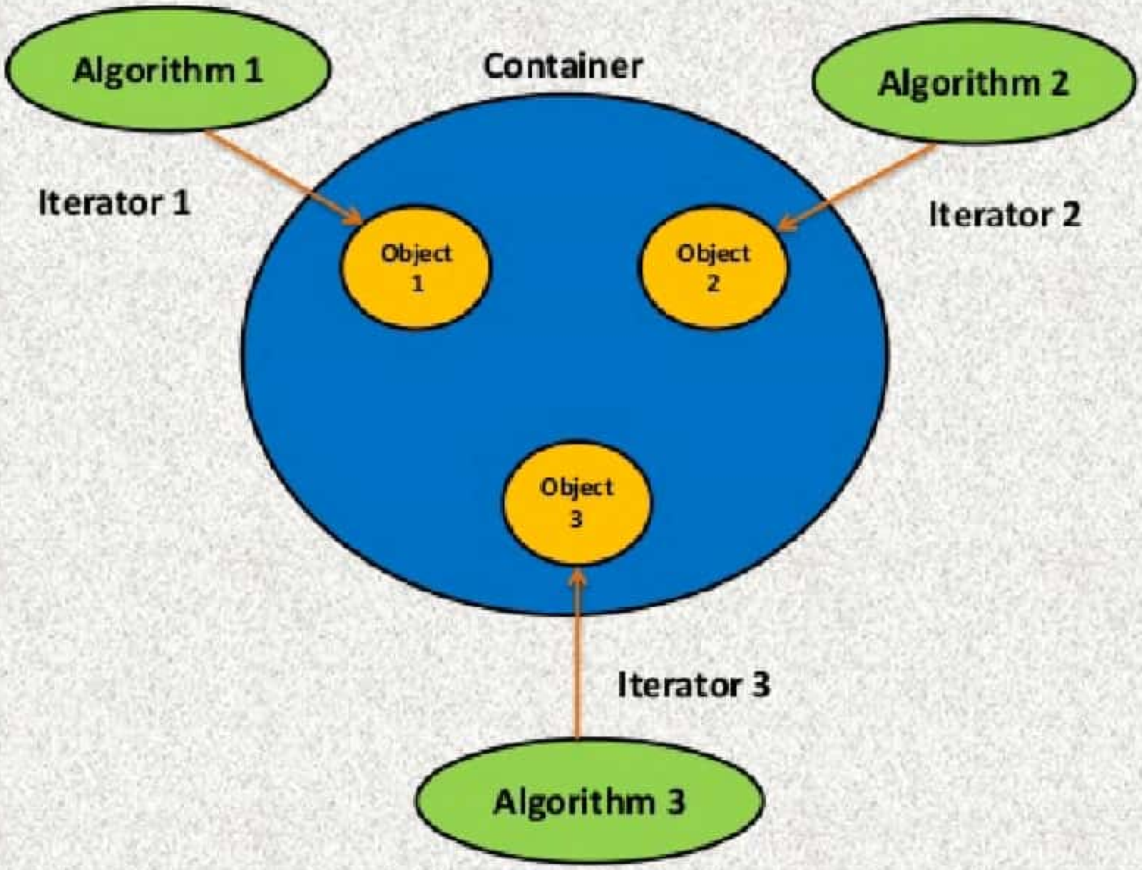
Relationship between Three STL Components



Algorithm 1

Container

Algorithm 2

Iterator 1

Iterator 2

Object 1

Object 2

Object 3

Iterator 3

Algorithm 3

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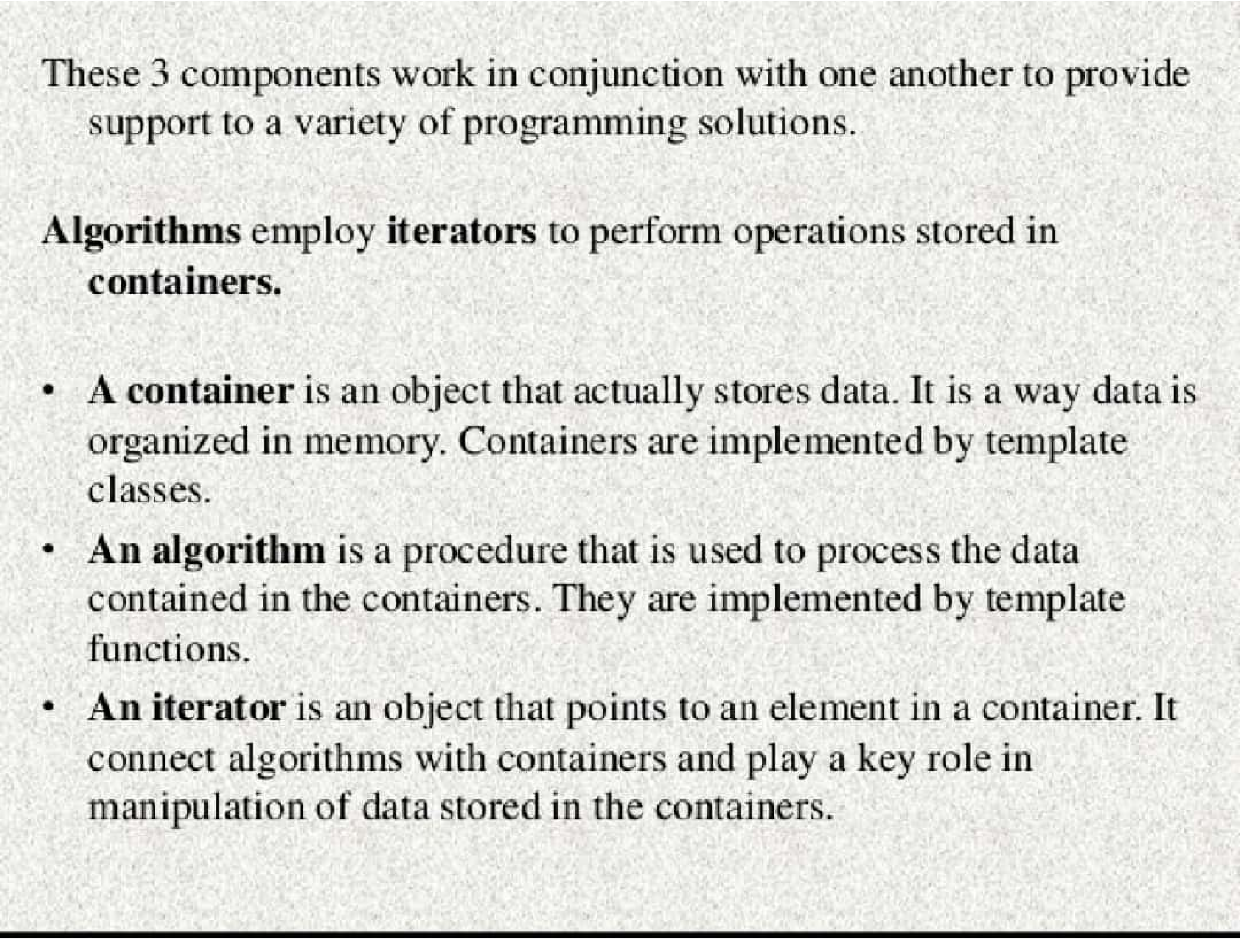

These 3 components work in conjunction with one another to provide support to a variety of programming solutions.

Algorithms employ **iterators** to perform operations stored in **containers.**

- **A container** is an object that actually stores data. It is a way data is organized in memory. Containers are implemented by template classes.
- **An algorithm** is a procedure that is used to process the data contained in the containers. They are implemented by template functions.
- **An iterator** is an object that points to an element in a container. It connect algorithms with containers and play a key role in manipulation of data stored in the containers.

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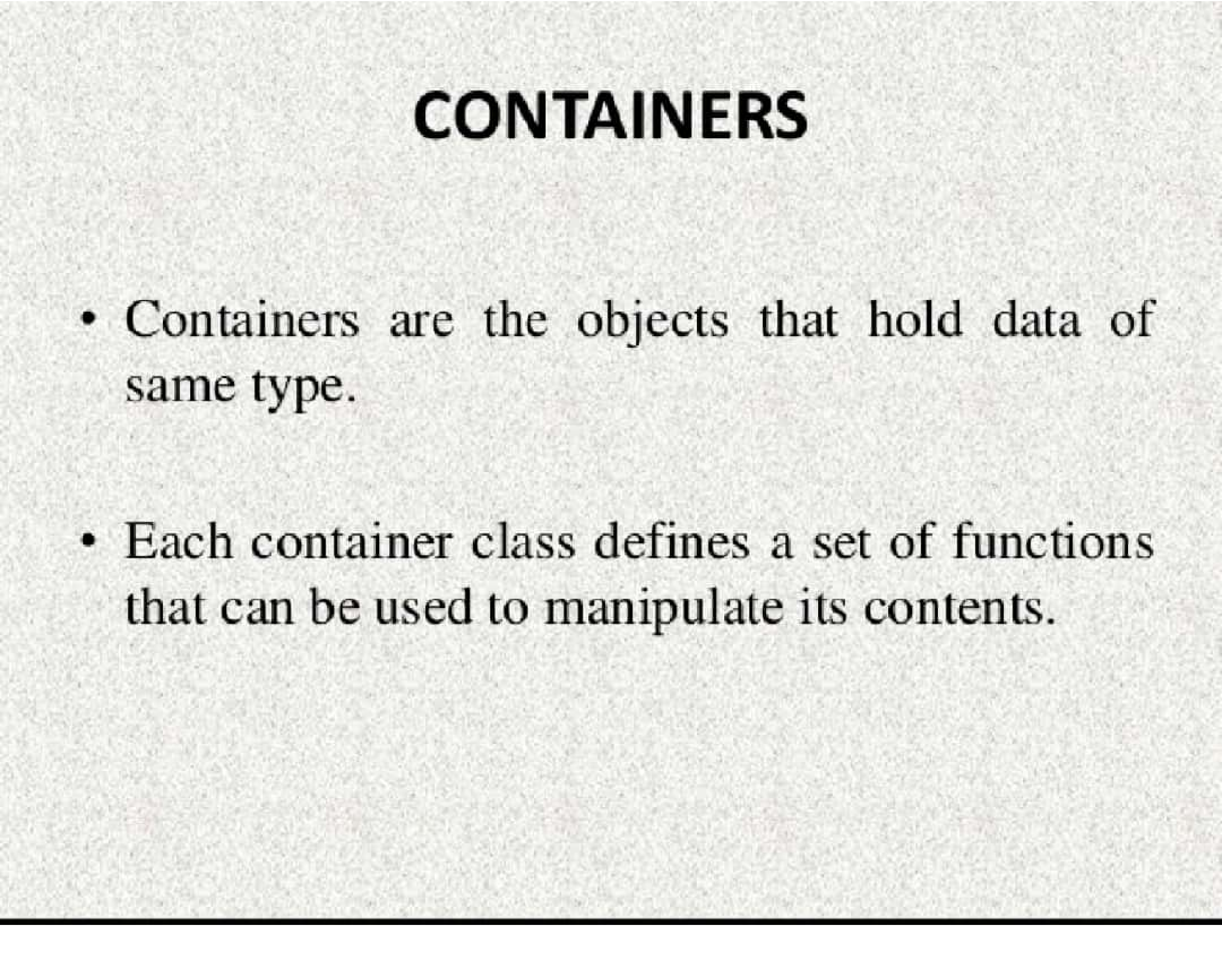

CONTAINERS

- Containers are the objects that hold data of same type.

- Each container class defines a set of functions that can be used to manipulate its contents.

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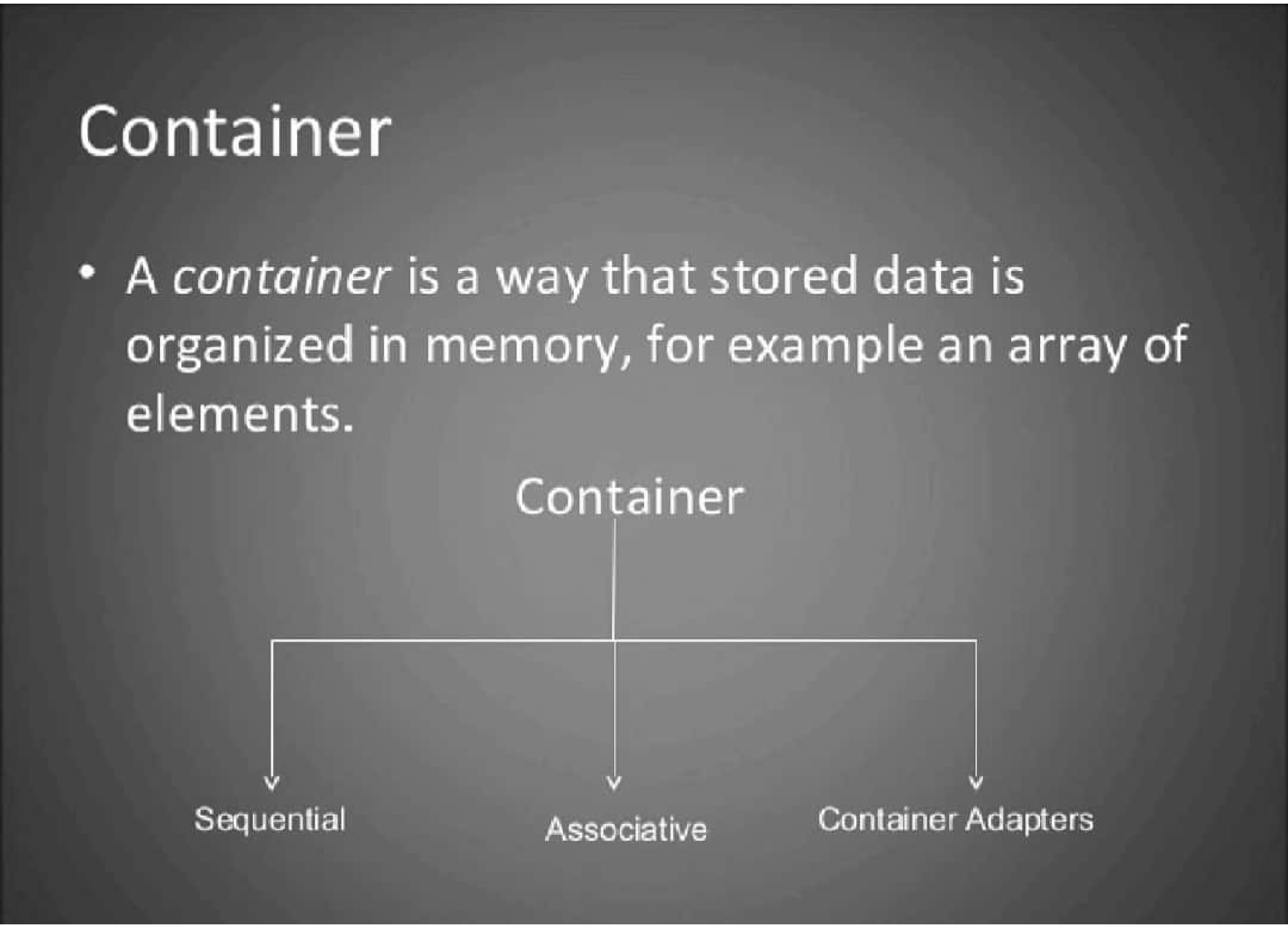

Container

- A *container* is a way that stored data is organized in memory, for example an array of elements.

Container

Sequential

Associative

Container Adapters

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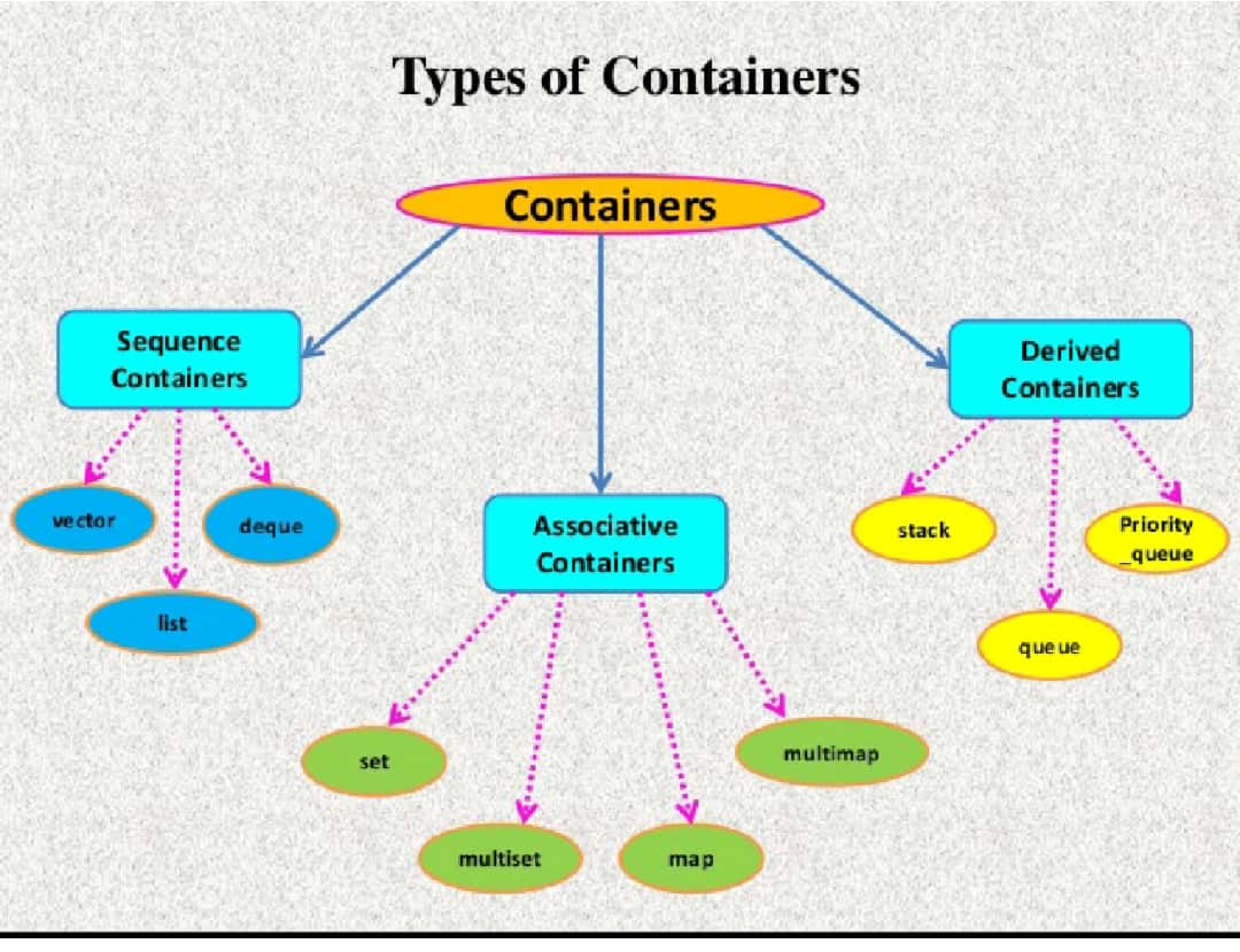

Types of Containers

Containers

Sequence Containers

vector

deque

list

Associative Containers

set

multiset

map

multimap

Derived Containers

stack

Priority _queue

queue

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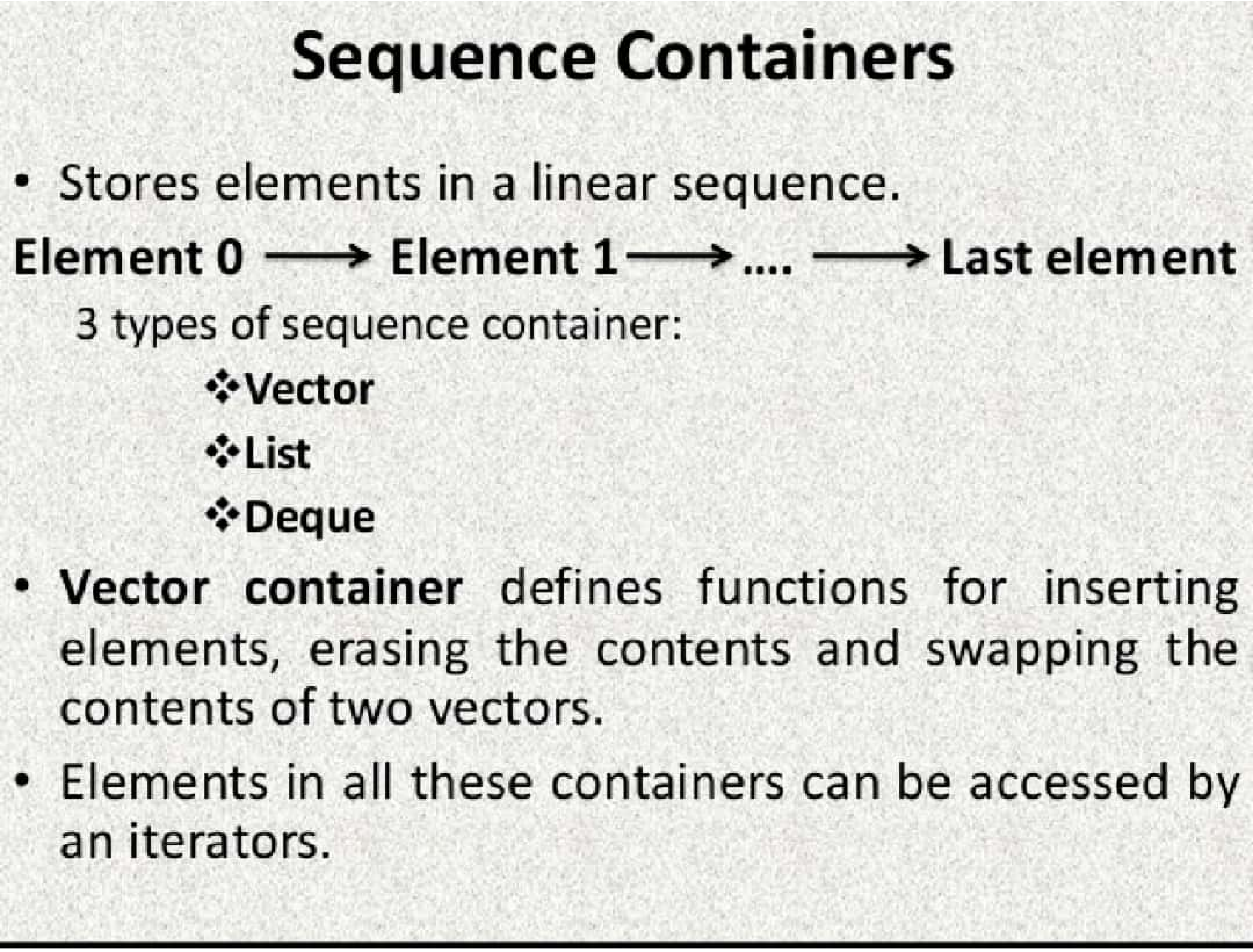

Sequence Containers

- Stores elements in a linear sequence.

Element 0 → Element 1 → .... → Last element

3 types of sequence container:

- **Vector**
- **List**
- **Deque**

- **Vector container** defines functions for inserting elements, erasing the contents and swapping the contents of two vectors.
- Elements in all these containers can be accessed by an iterators.

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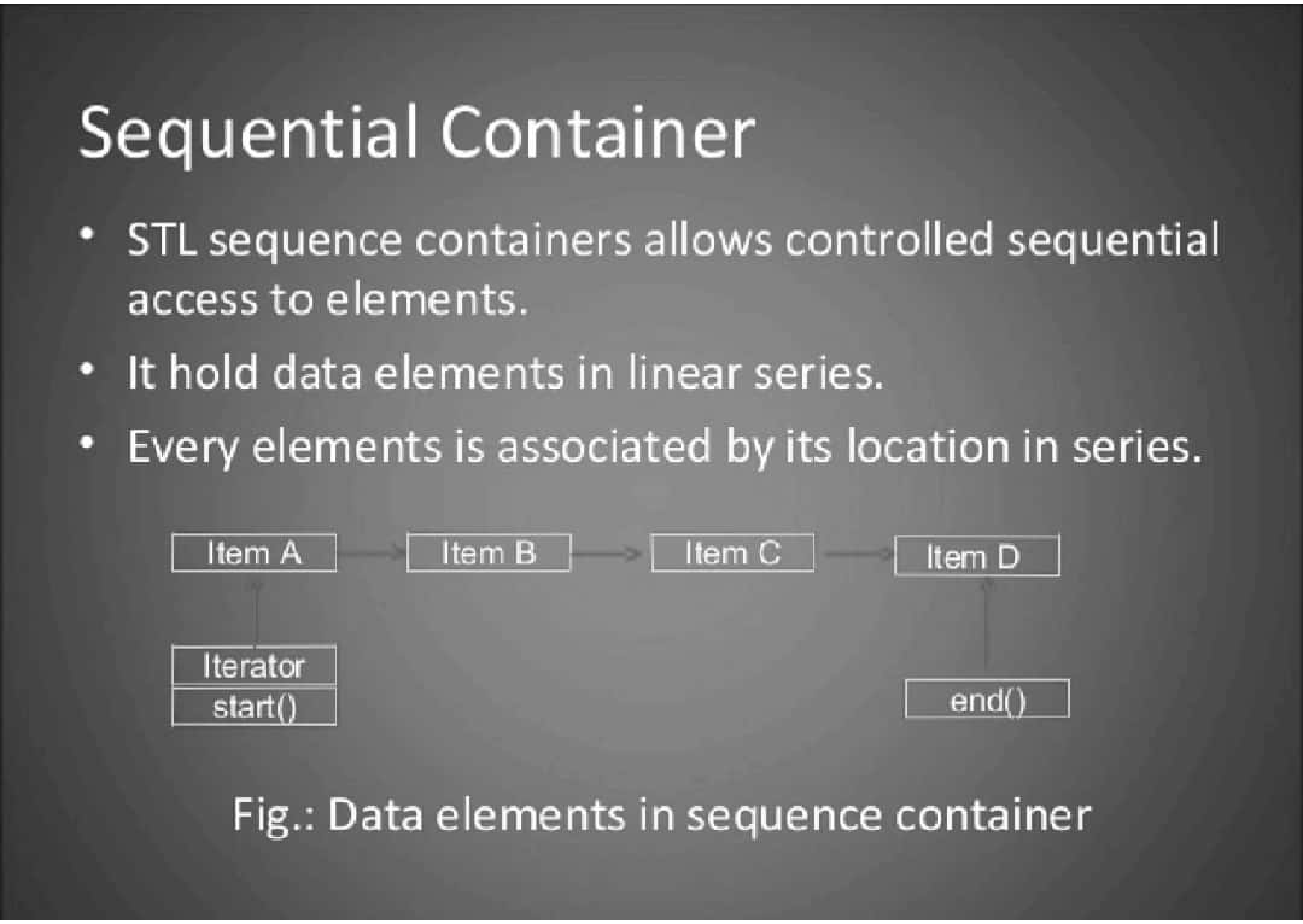

Sequential Container

- STL sequence containers allows controlled sequential access to elements.
- It hold data elements in linear series.
- Every elements is associated by its location in series.

Fig.: Data elements in sequence container

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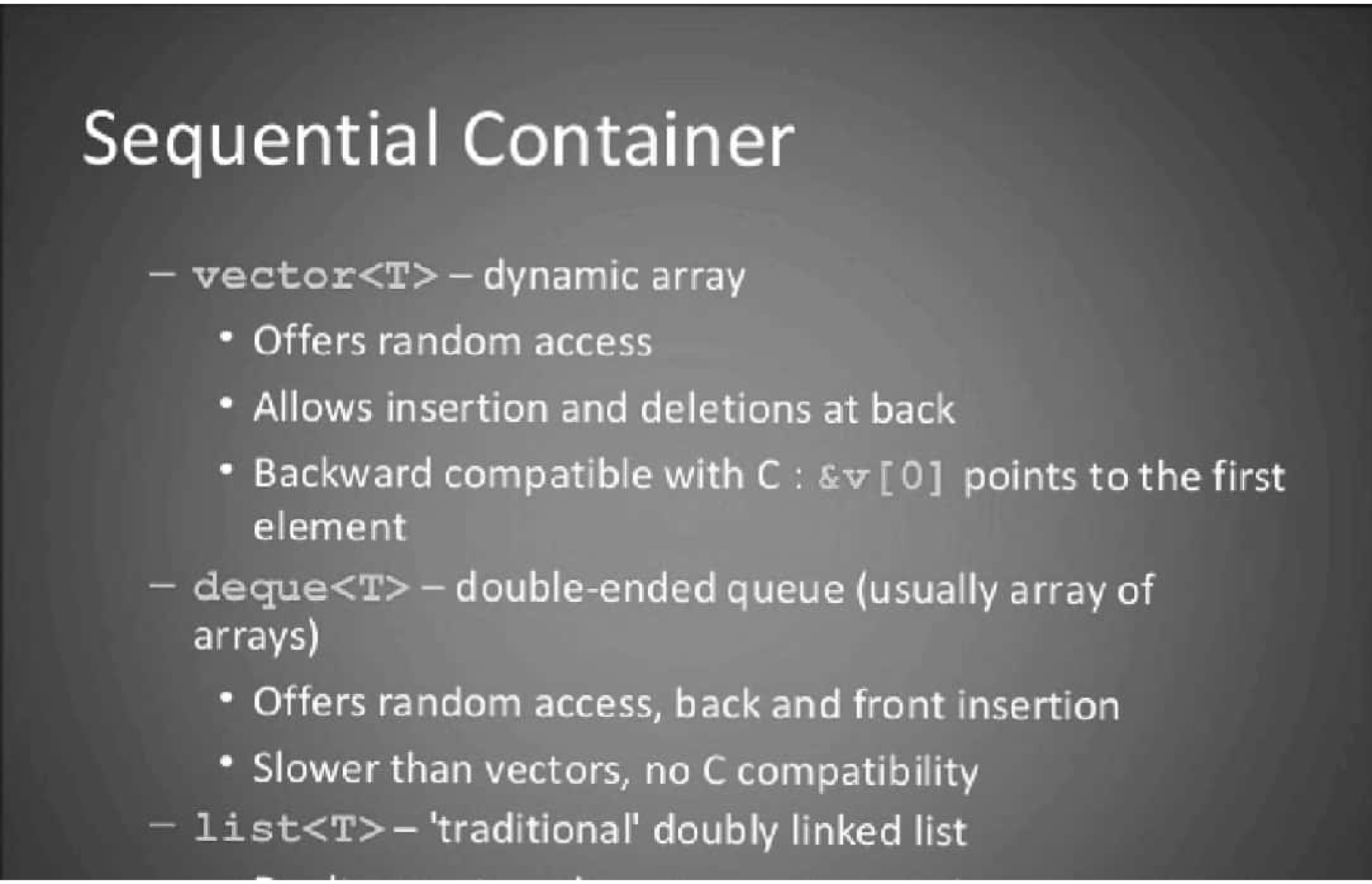

Sequential Container

- `vector<T>` – dynamic array
  - Offers random access
  - Allows insertion and deletions at back
  - Backward compatible with C : `&v[0]` points to the first element
- `deque<T>` – double-ended queue (usually array of arrays)
  - Offers random access, back and front insertion
  - Slower than vectors, no C compatibility
- `list<T>` – 'traditional' doubly linked list

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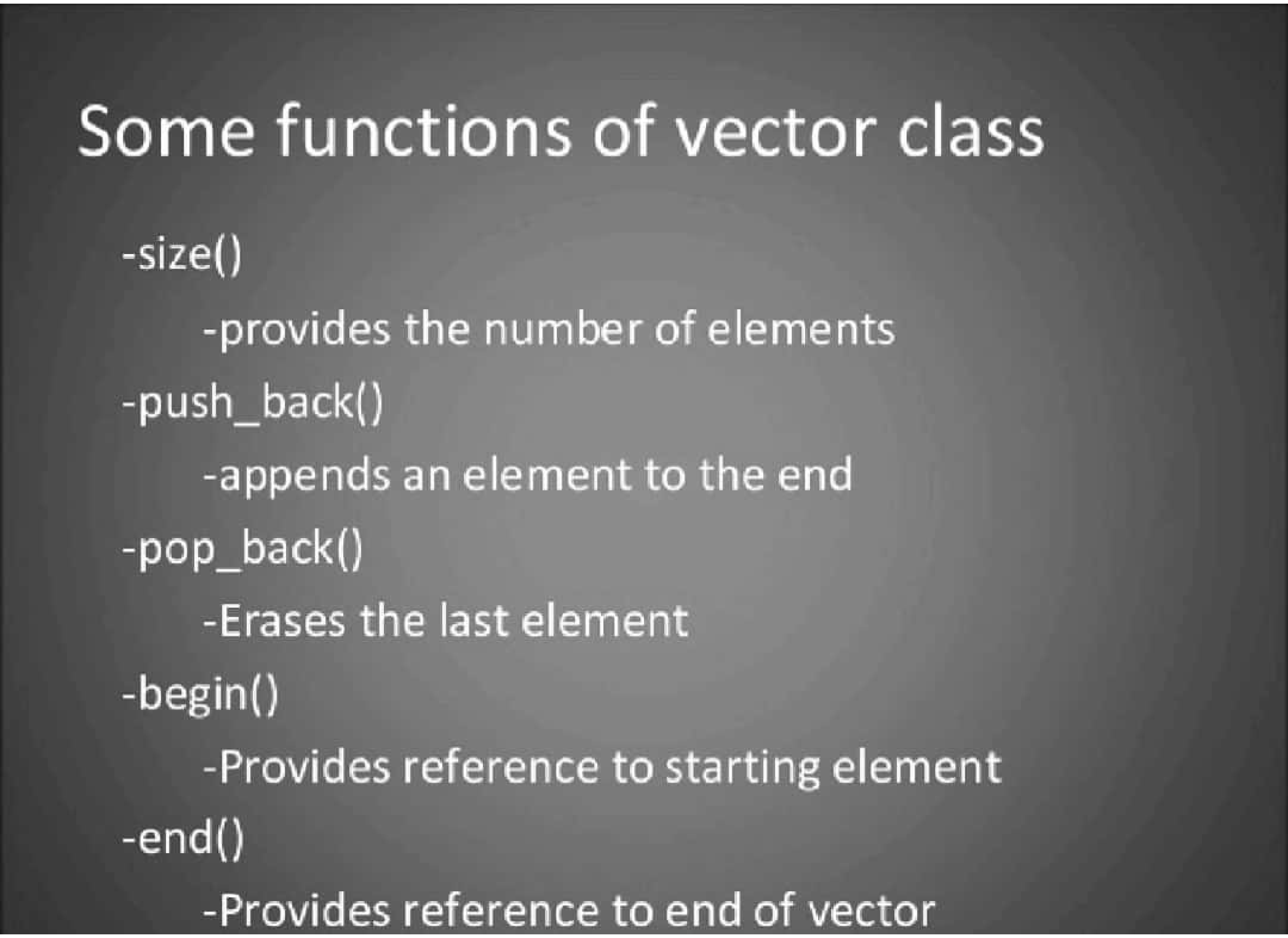

Some functions of vector class

-size()

-provides the number of elements

-push_back()

-appends an element to the end

-pop_back()

-Erases the last element

-begin()

-Provides reference to starting element

-end()

-Provides reference to end of vector

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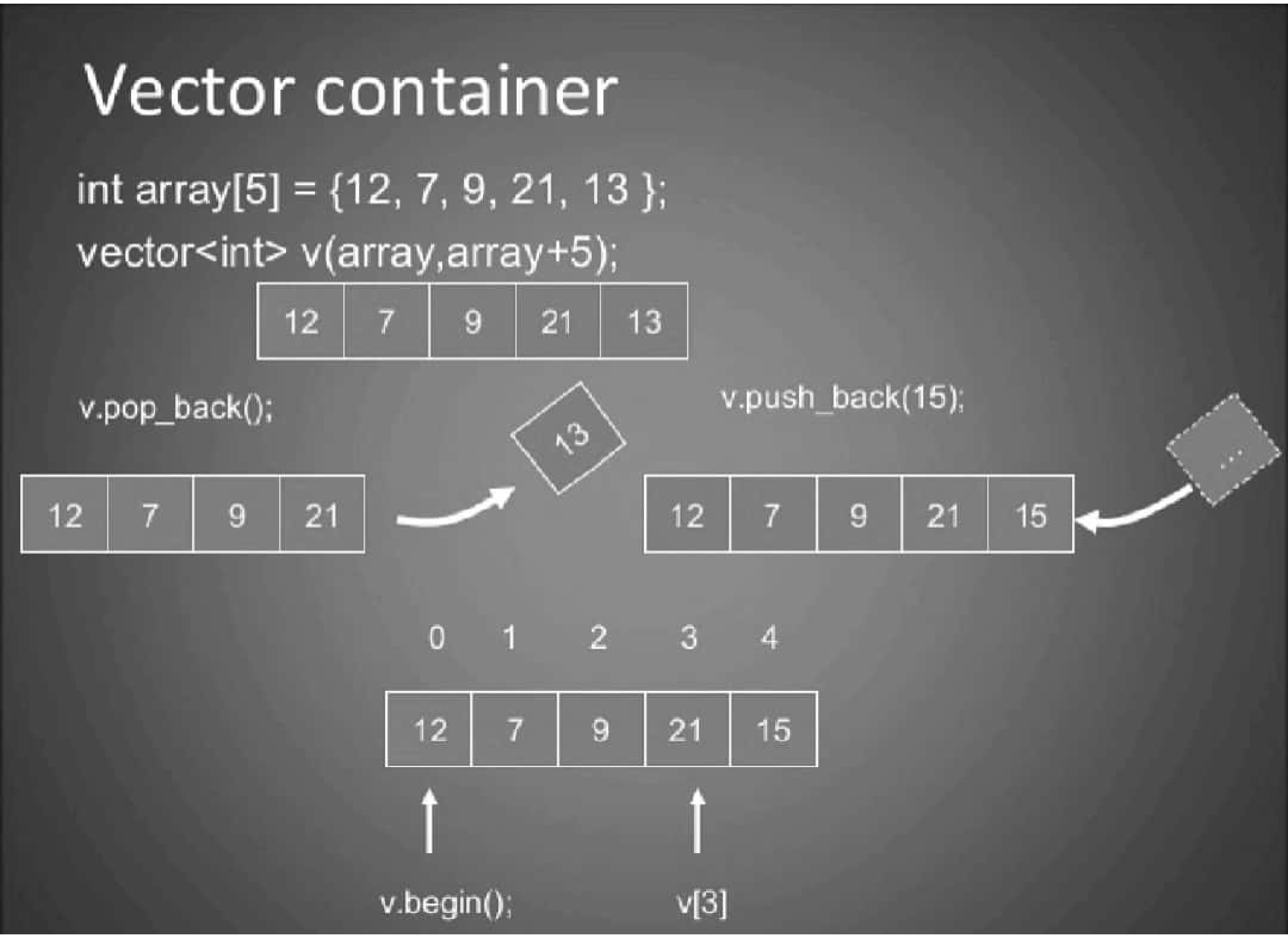

Vector container

```
int array[5] = {12, 7, 9, 21, 13 };
vector<int> v(array,array+5);
```

12	7	9	21	13

v.pop_back();

12	7	9	21

v.push_back(15);

12	7	9	21	15

0	1	2	3	4
12	7	9	21	15

v.begin();

v[3]

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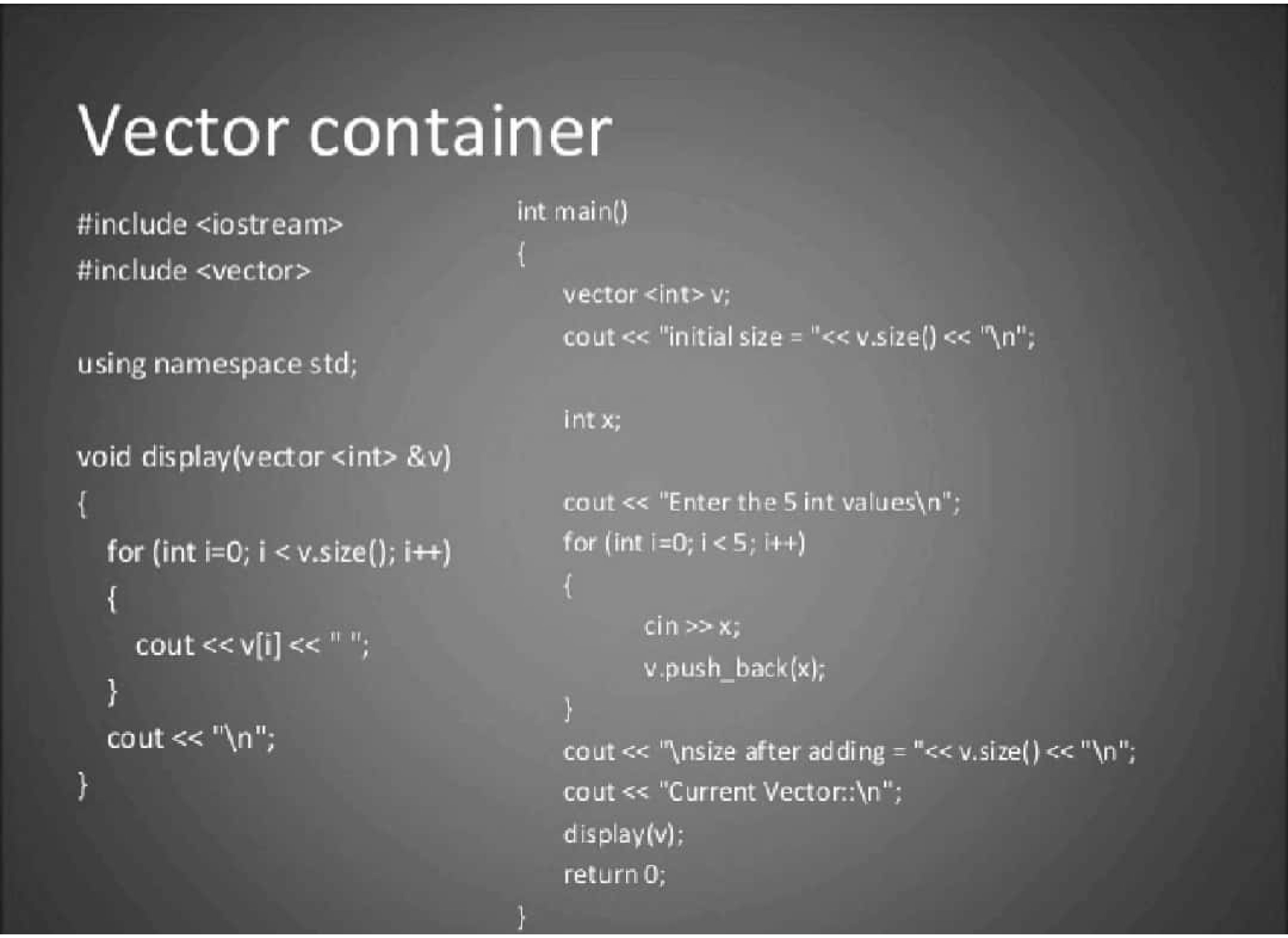

Vector container

```
#include <iostream>
#include <vector>

using namespace std;

void display(vector <int> &v)
{
   for (int i=0; i < v.size(); i++)
   {
      cout << v[i] << " ";
   }
   cout << "\n";
}
```

```
int main()
{
      vector <int> v;
      cout << "initial size = "<< v.size() << "\n";

      int x;

      cout << "Enter the 5 int values\n";
      for (int i=0; i < 5; i++)
      {
            cin >> x;
            v.push_back(x);
      }
      cout << "\nsize after adding = "<< v.size() << "\n";
      cout << "Current Vector::\n";
      display(v);
      return 0;
}
```

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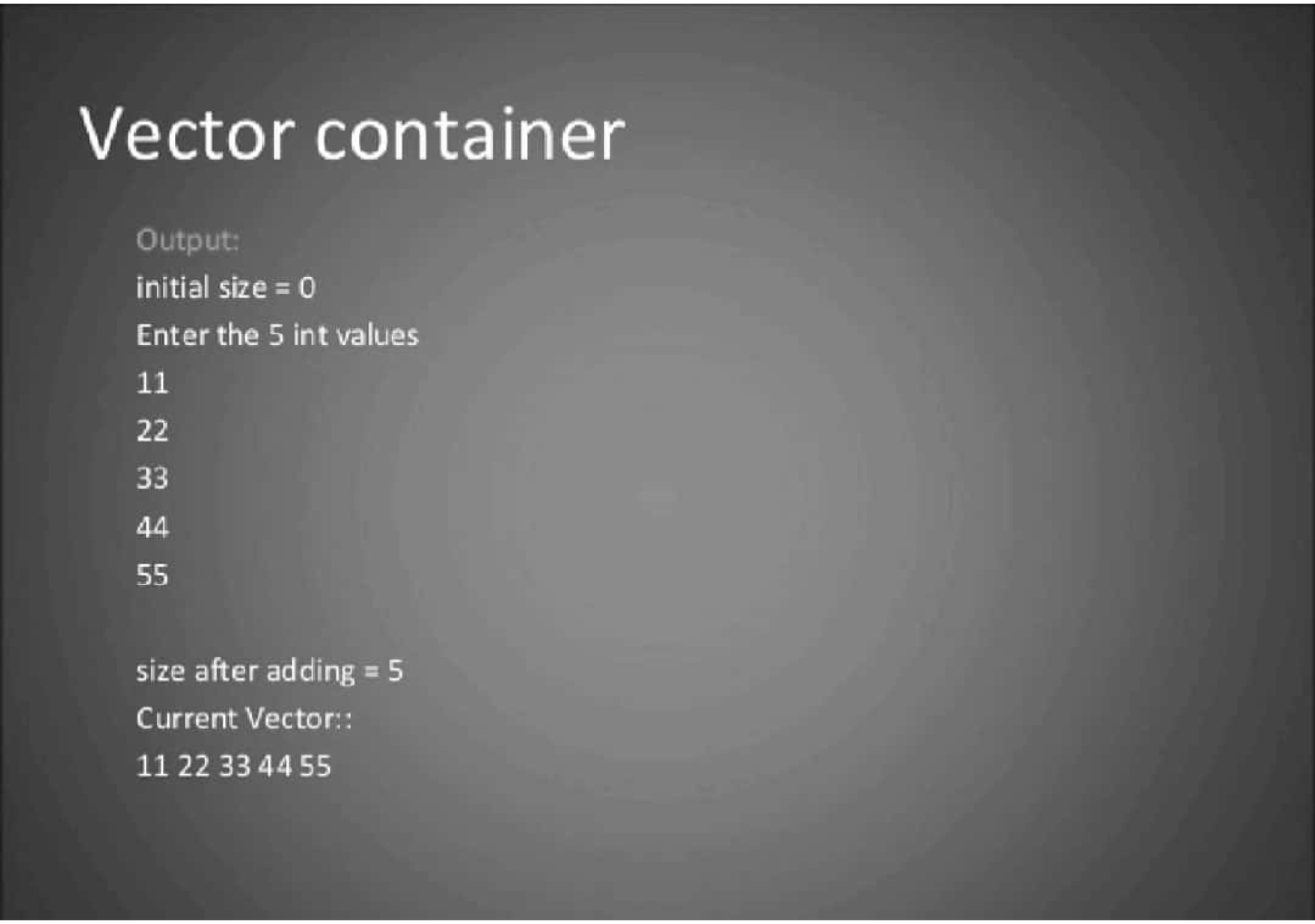

Vector container

```
Output:
initial size = 0
Enter the 5 int values
11
22
33
44
55

size after adding = 5
Current Vector::
11 22 33 44 55
```

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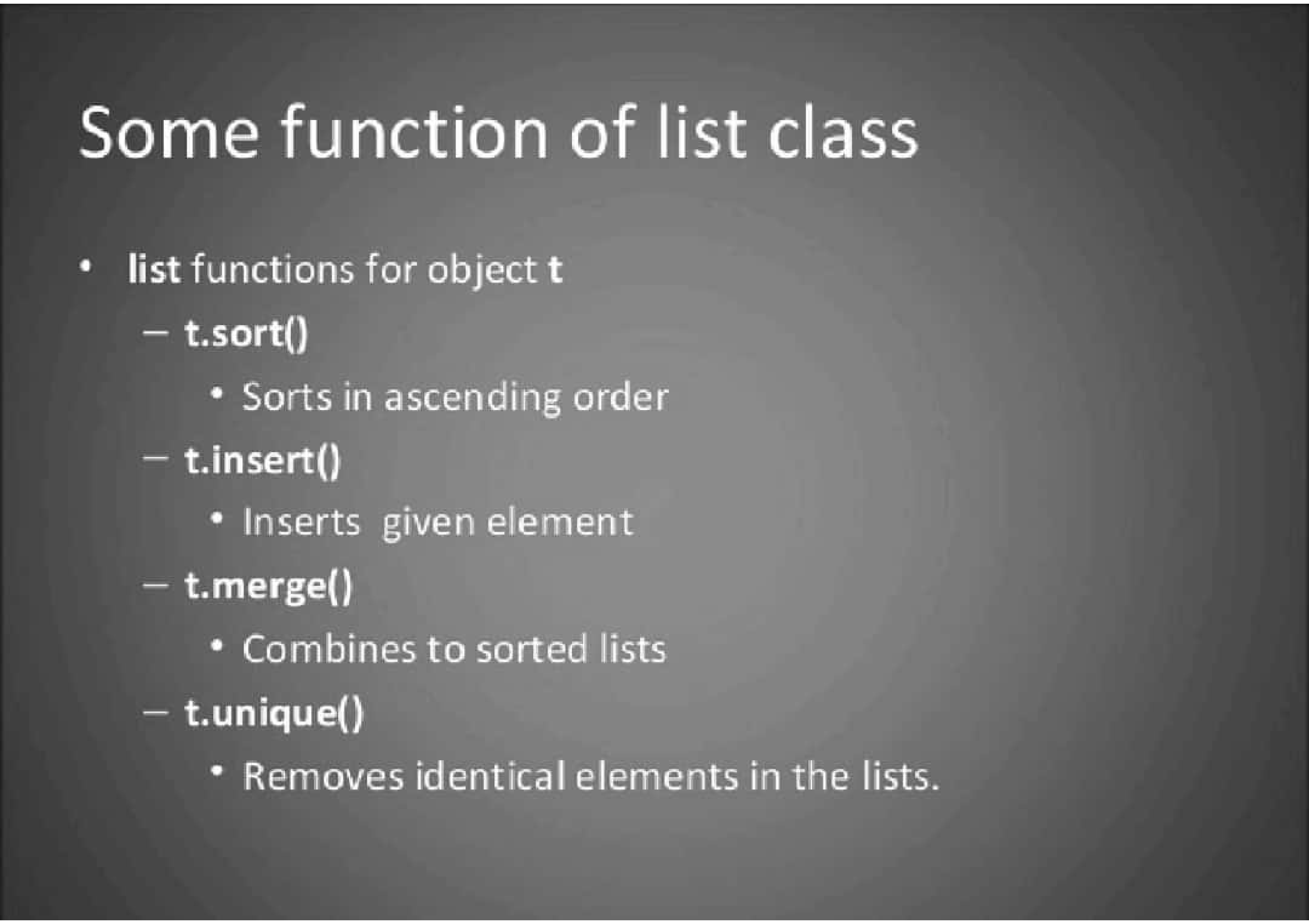

Some function of list class

- **list** functions for object **t**
  - **t.sort()**
    - Sorts in ascending order
  - **t.insert()**
    - Inserts given element
  - **t.merge()**
    - Combines to sorted lists
  - **t.unique()**
    - Removes identical elements in the lists.

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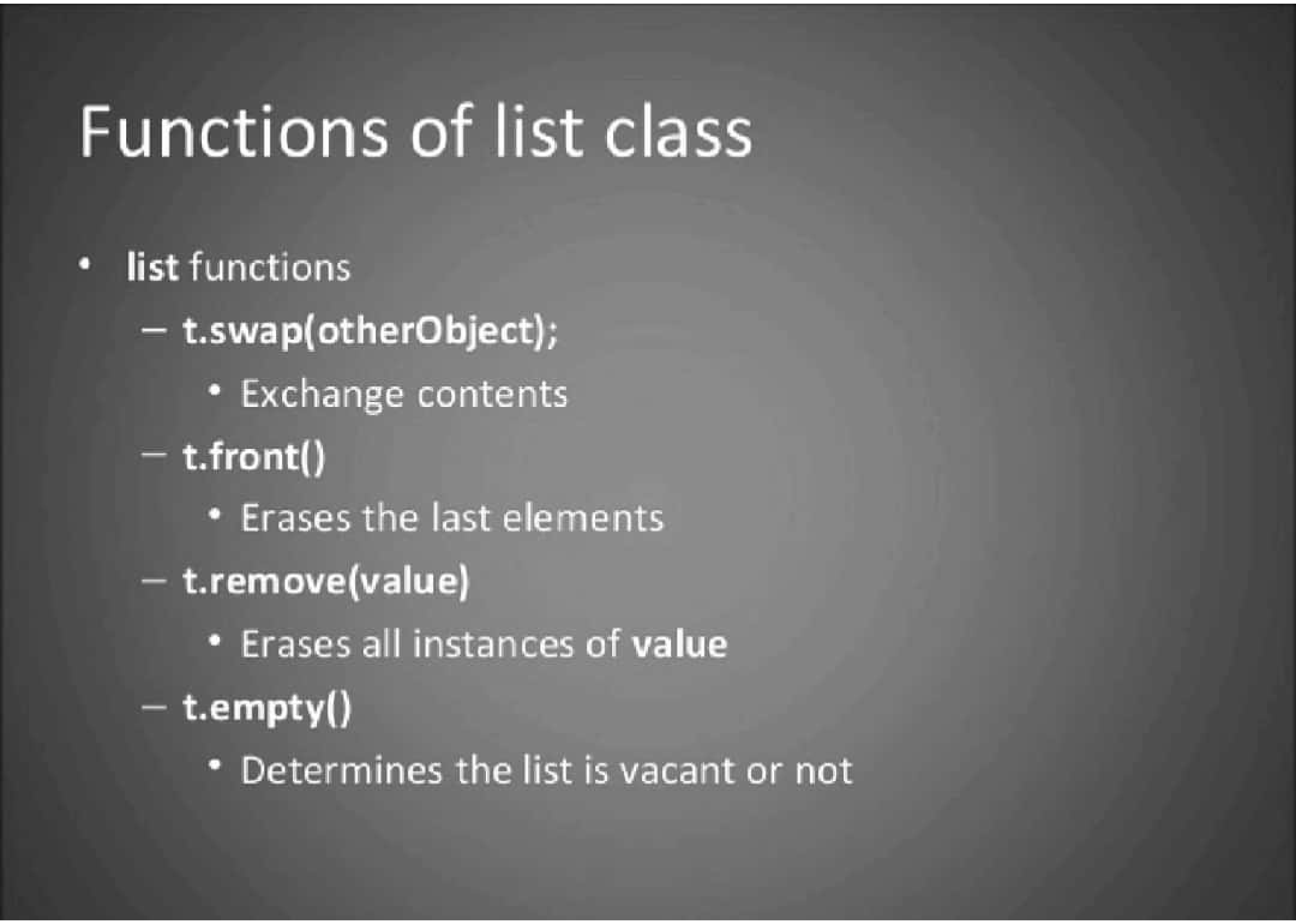

Functions of list class

- **list** functions
  - **t.swap(otherObject);**
    - Exchange contents
  - **t.front()**
    - Erases the last elements
  - **t.remove(value)**
    - Erases all instances of **value**
  - **t.empty()**
    - Determines the list is vacant or not

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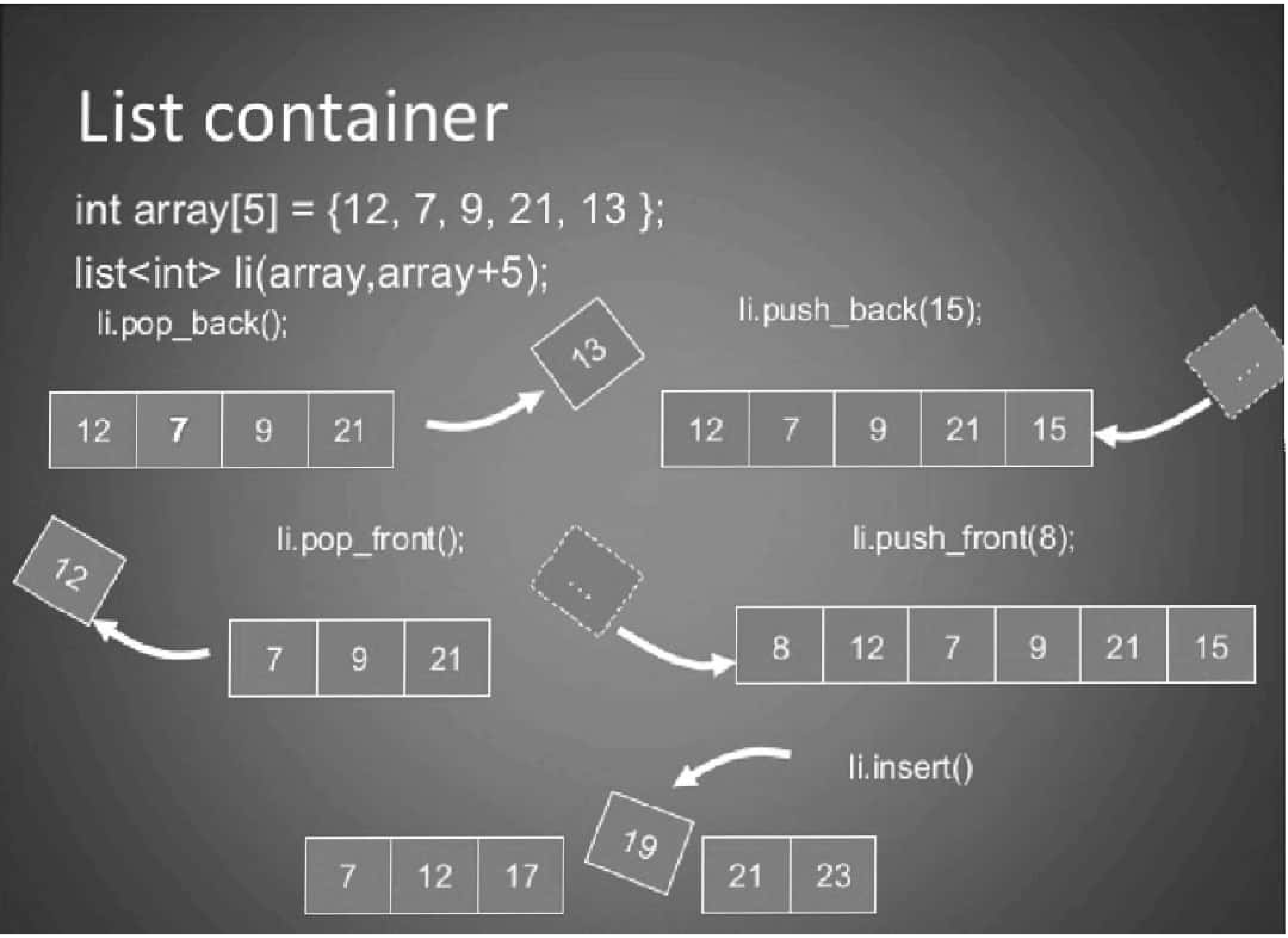


List container

```
int array[5] = {12, 7, 9, 21, 13 };
list<int> li(array,array+5);
```

li.pop_back();

12	7	9	21

li.push_back(15);

12	7	9	21	15

li.pop_front();

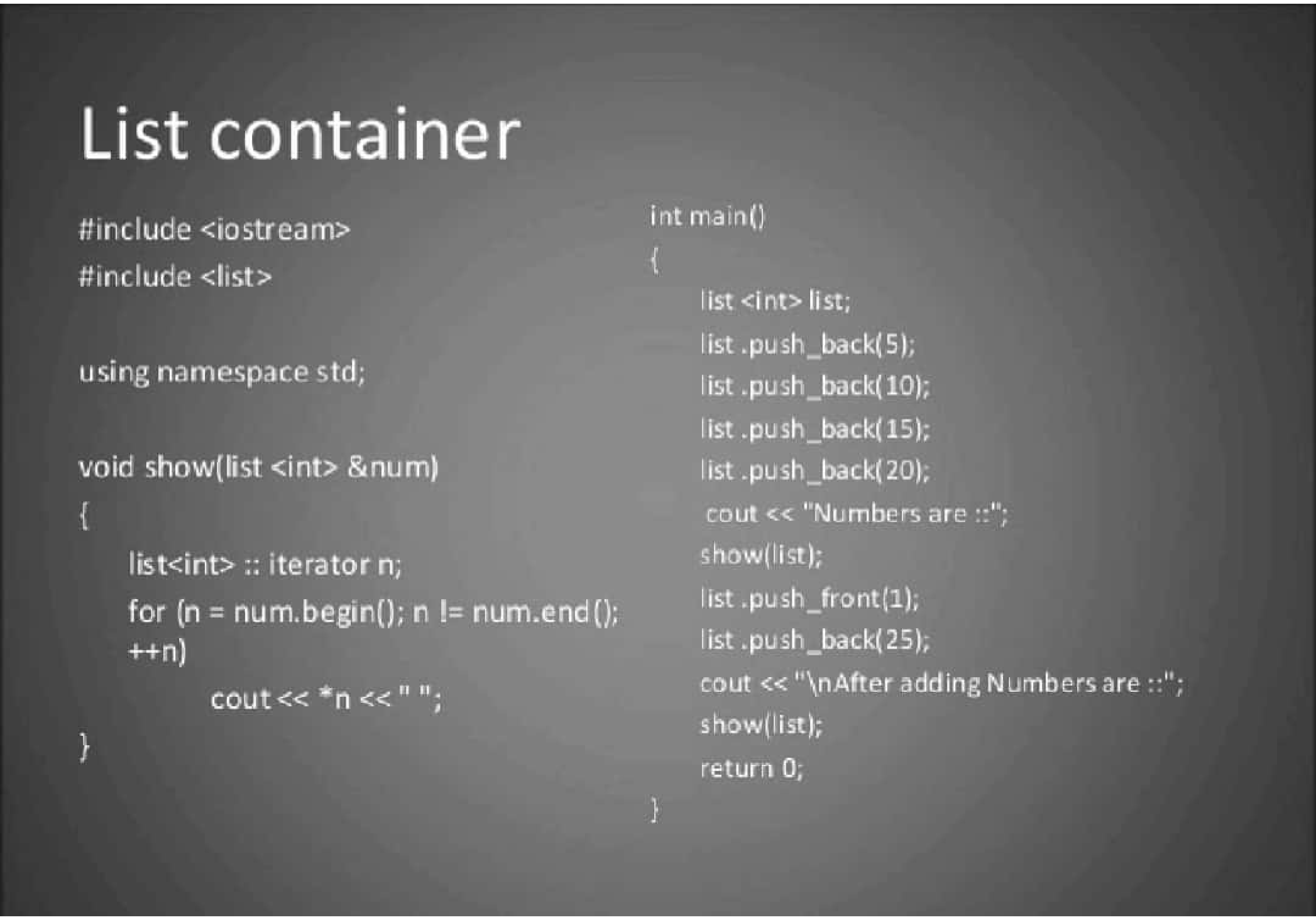
7	9	21

li.push_front(8);

8	12	7	9	21	15

li.insert()

7	12	17		21	23



List container

```
#include <iostream>
#include <list>

using namespace std;

void show(list <int> &num)
{
    list<int> :: iterator n;
    for (n = num.begin(); n != num.end();
    ++n)
        cout << *n << " ";
}
```

```
int main()
{
    list <int> list;
    list .push_back(5);
    list .push_back(10);
    list .push_back(15);
    list .push_back(20);
     cout << "Numbers are ::";
    show(list);
    list .push_front(1);
    list .push_back(25);
    cout << "\nAfter adding Numbers are ::";
    show(list);
    return 0;
}
```

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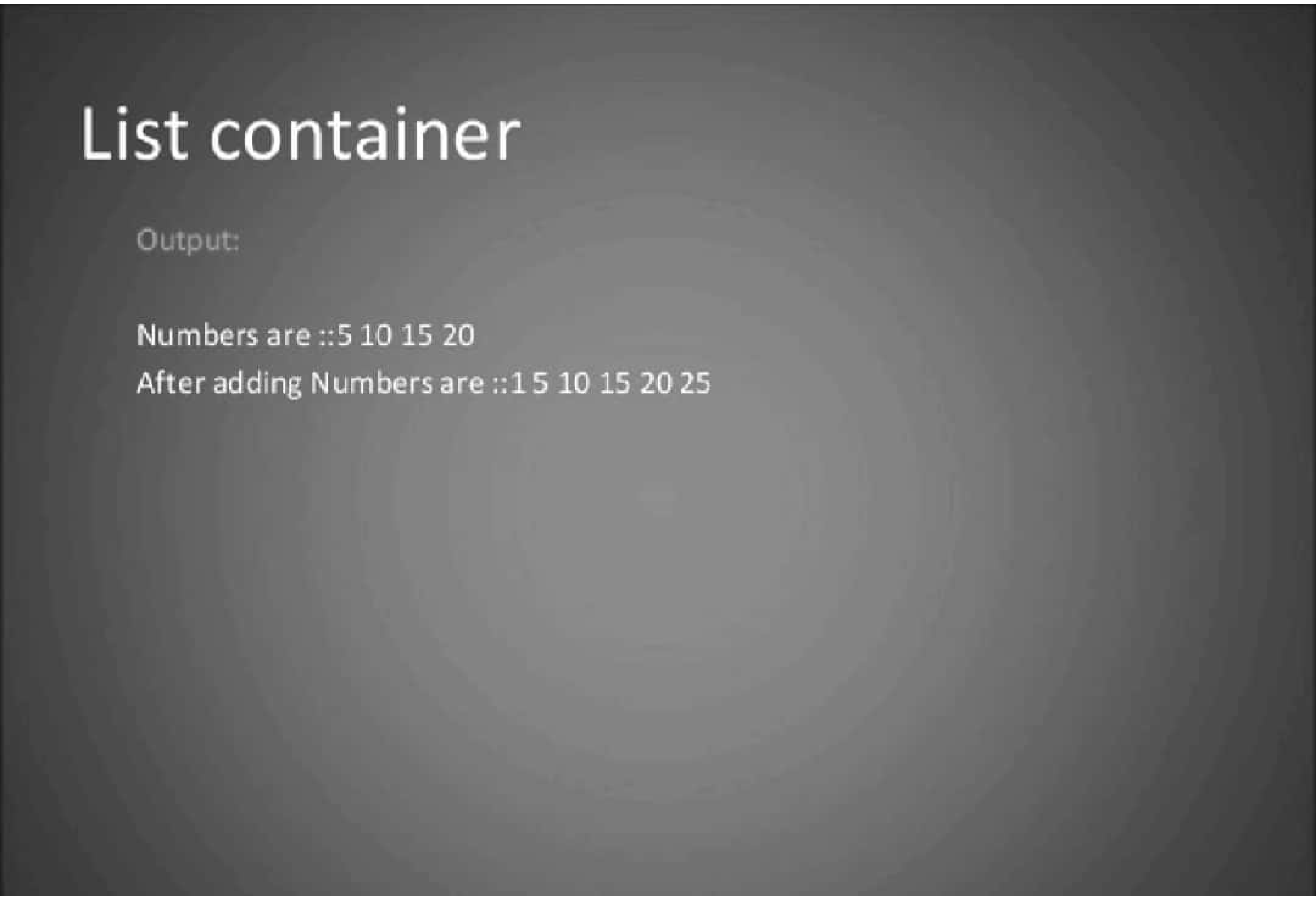

List container

Output:

```
Numbers are ::5 10 15 20
After adding Numbers are ::1 5 10 15 20 25
```

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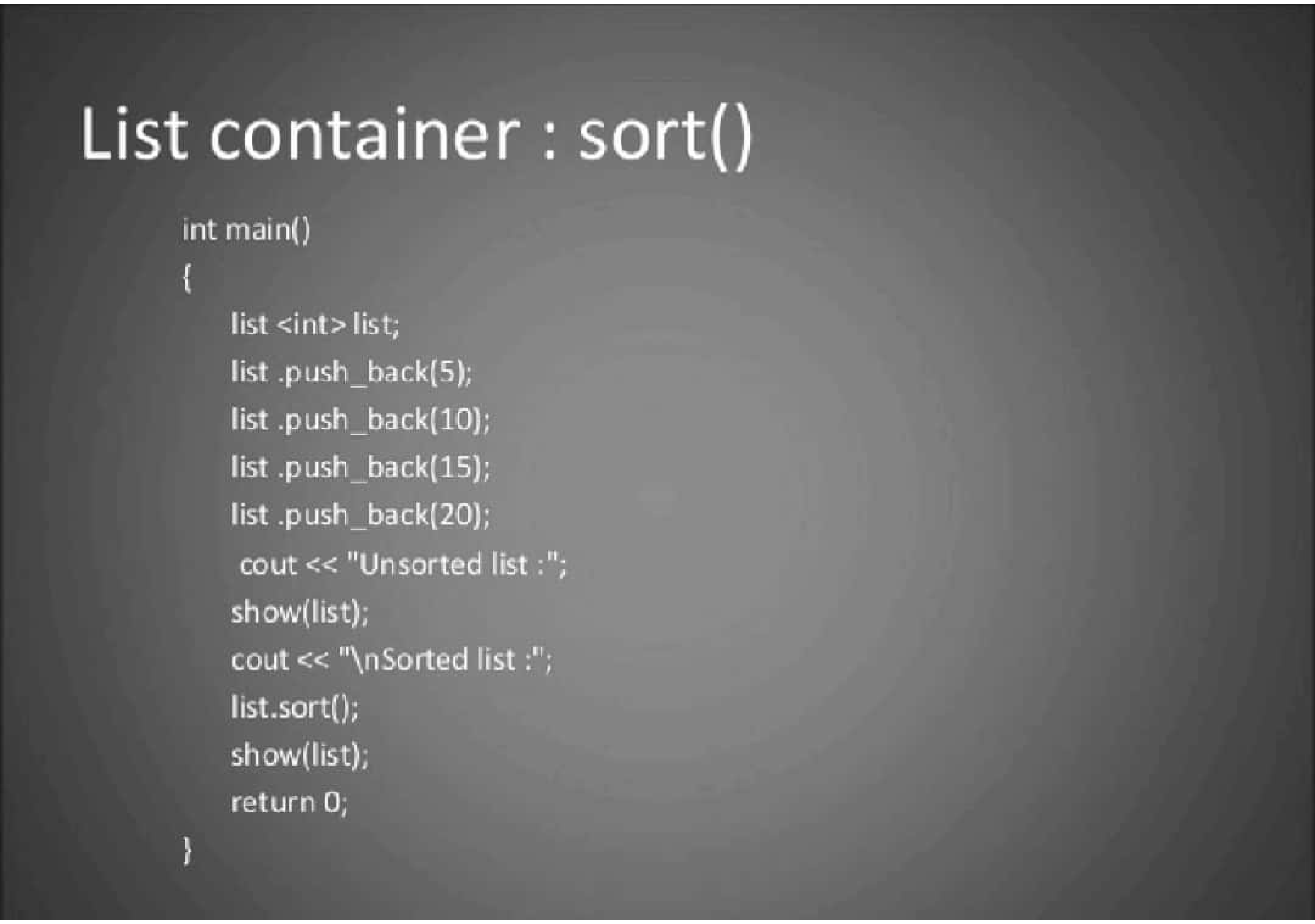

List container : sort()

```
int main()
{
    list <int> list;
    list .push_back(5);
    list .push_back(10);
    list .push_back(15);
    list .push_back(20);
     cout << "Unsorted list :";
    show(list);
    cout << "\nSorted list :";
    list.sort();
    show(list);
    return 0;
}
```

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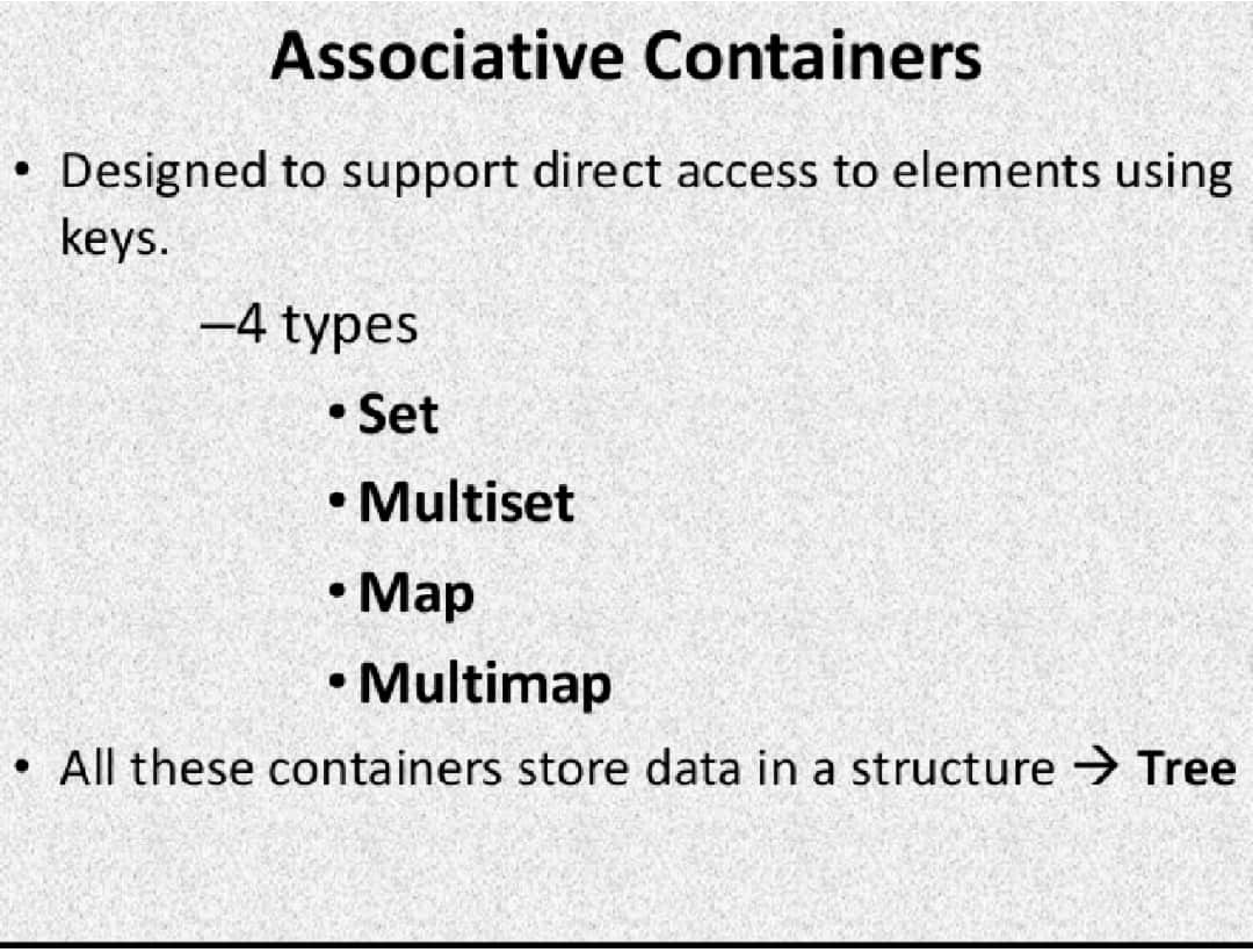

Associative Containers

- Designed to support direct access to elements using keys.
  - –4 types
    - **Set**
    - **Multiset**
    - **Map**
    - **Multimap**
- All these containers store data in a structure → **Tree**

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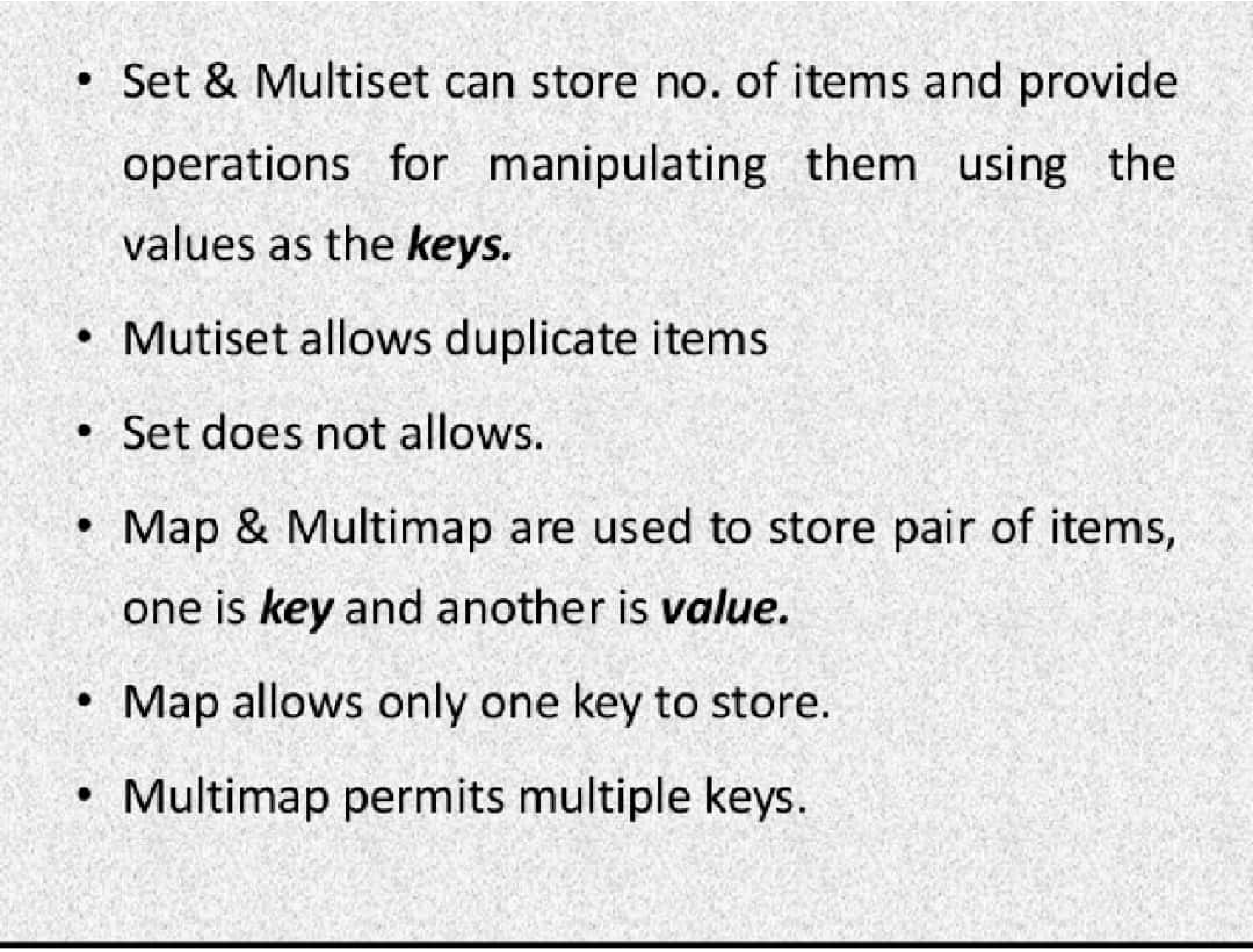

- Set & Multiset can store no. of items and provide operations for manipulating them using the values as the ***keys.***
- Mutiset allows duplicate items
- Set does not allows.
- Map & Multimap are used to store pair of items, one is ***key*** and another is ***value.***
- Map allows only one key to store.
- Multimap permits multiple keys.

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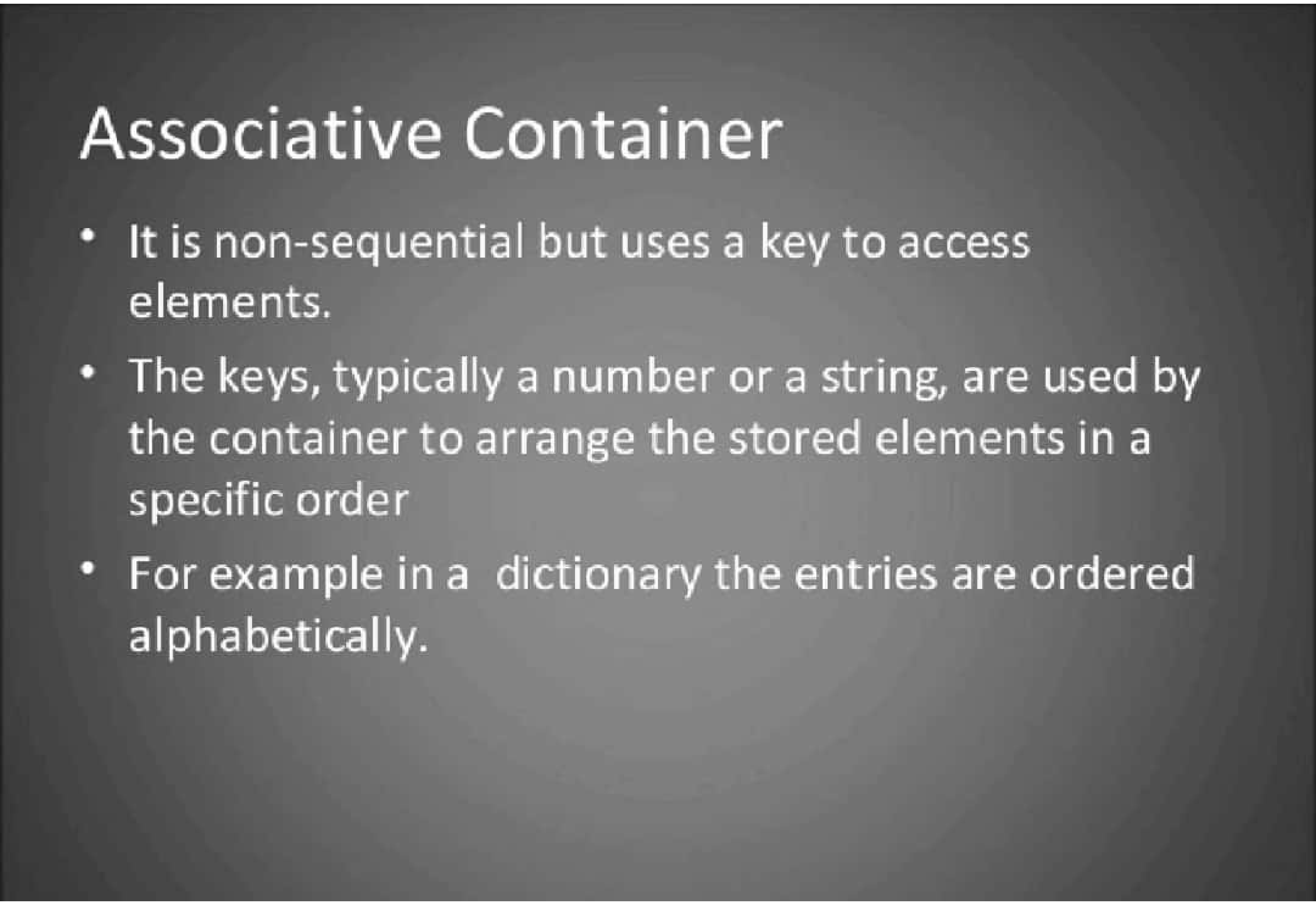

Associative Container

- It is non-sequential but uses a key to access elements.
- The keys, typically a number or a string, are used by the container to arrange the stored elements in a specific order
- For example in a dictionary the entries are ordered alphabetically.

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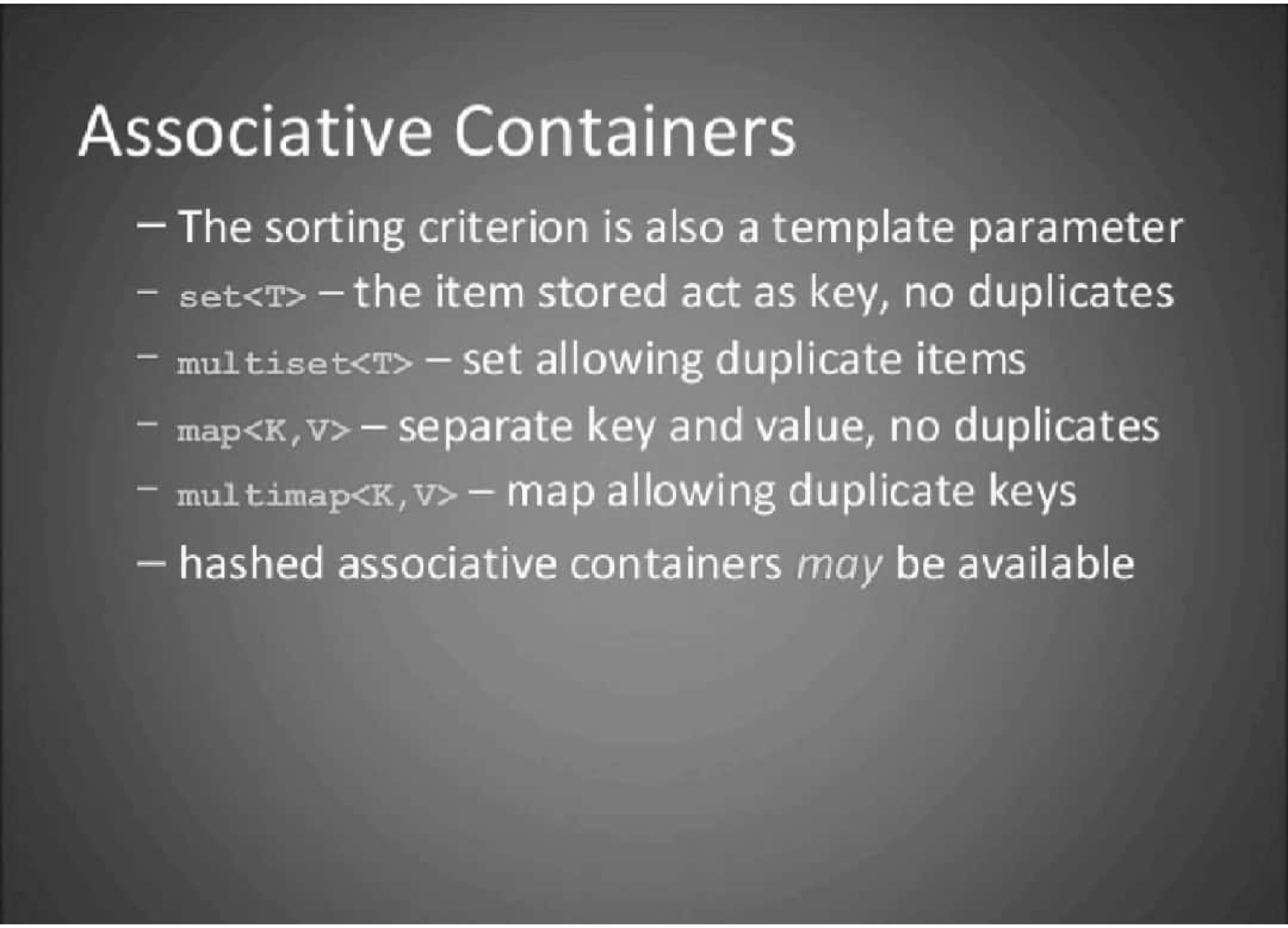

Associative Containers

- The sorting criterion is also a template parameter
- `set<T>` – the item stored act as key, no duplicates
- `multiset<T>` – set allowing duplicate items
- `map<K,V>` – separate key and value, no duplicates
- `multimap<K,V>` – map allowing duplicate keys
- hashed associative containers *may* be available

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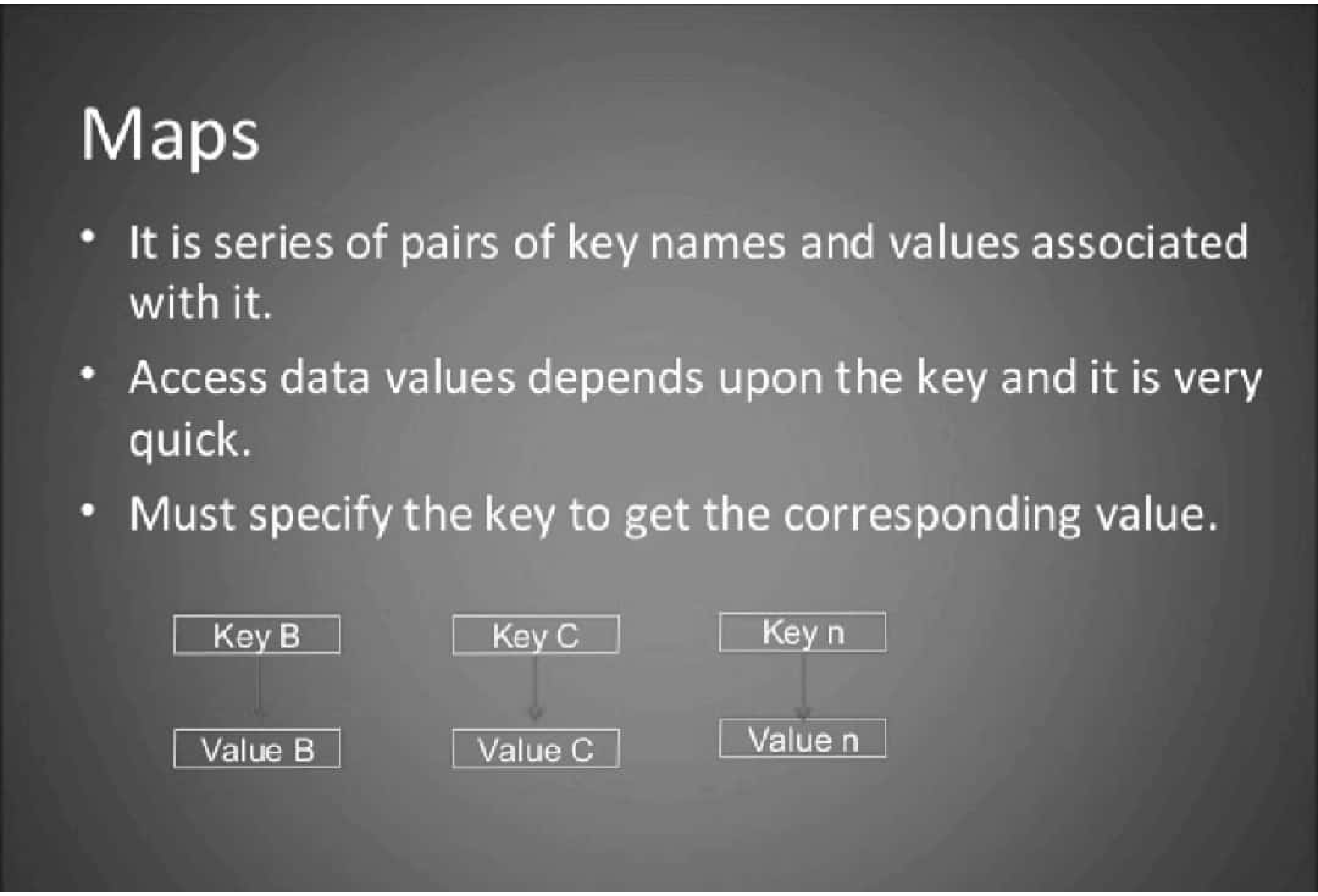

Maps

- It is series of pairs of key names and values associated with it.
- Access data values depends upon the key and it is very quick.
- Must specify the key to get the corresponding value.

Key B
Value B
Key C
Value C
Key n
Value n

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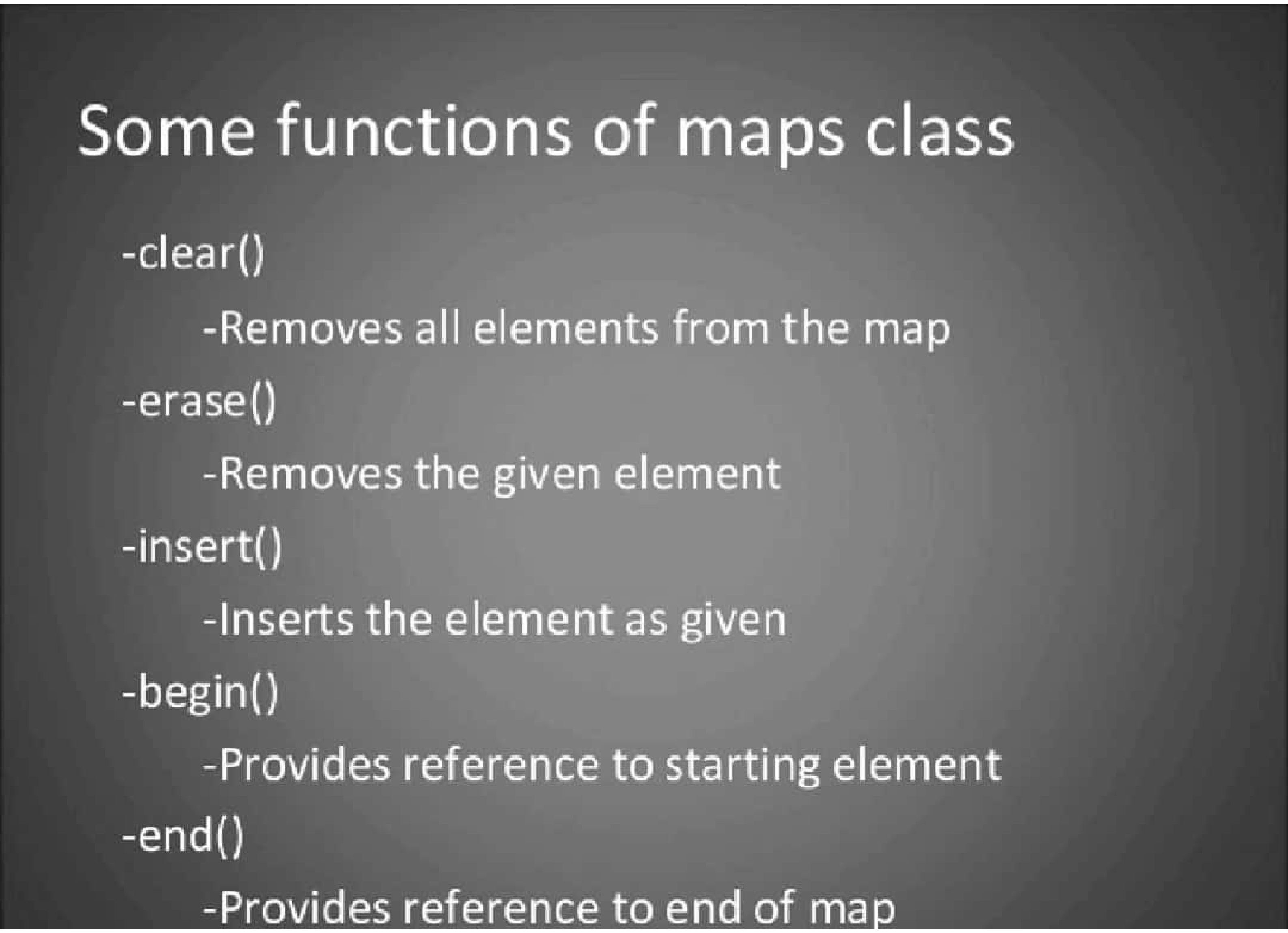

Some functions of maps class

-clear()

- -Removes all elements from the map

-erase()

- -Removes the given element

-insert()

- -Inserts the element as given

-begin()

- -Provides reference to starting element

-end()

- -Provides reference to end of map

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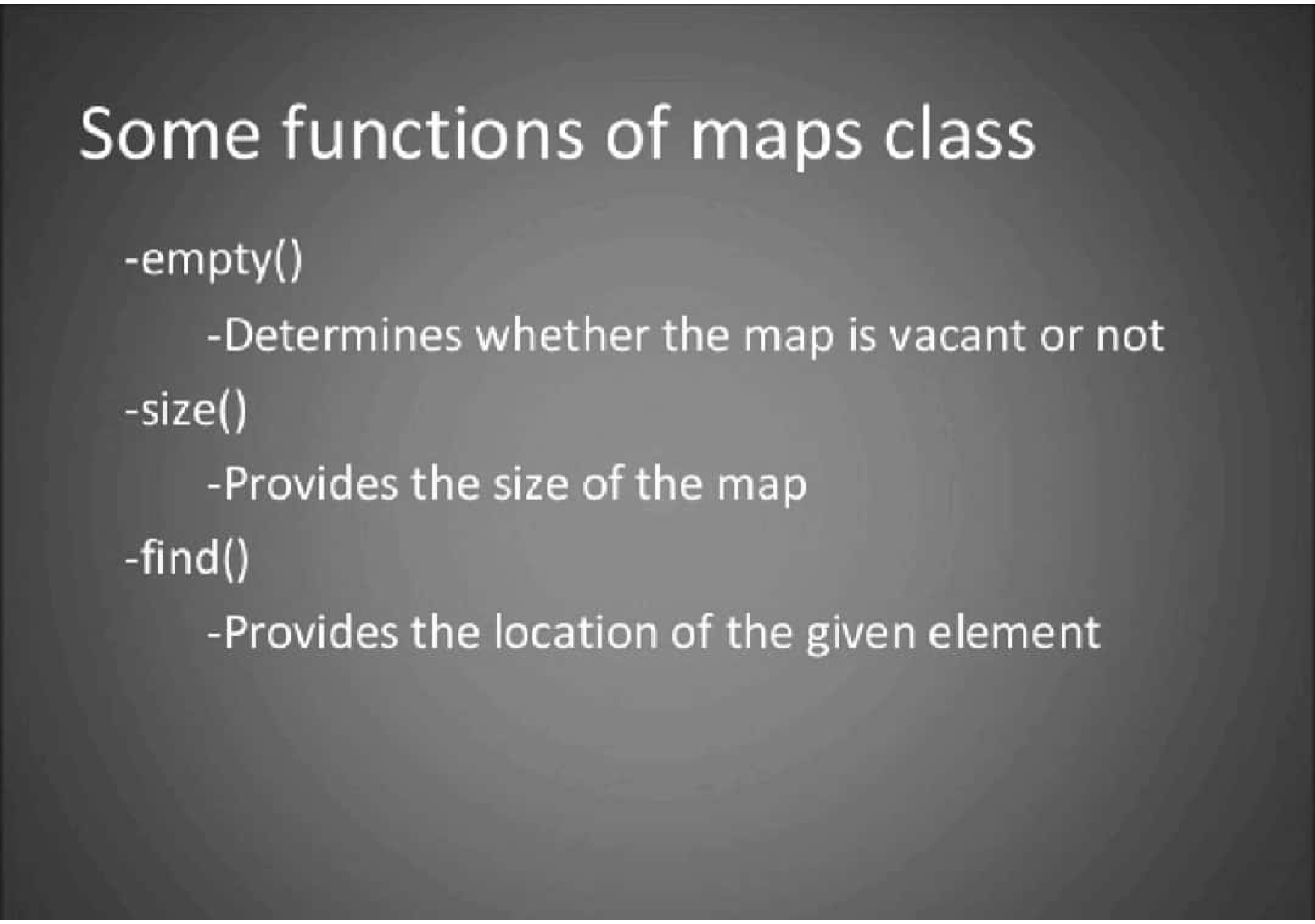

Some functions of maps class

-empty()

  -Determines whether the map is vacant or not

-size()

  -Provides the size of the map

-find()

  -Provides the location of the given element

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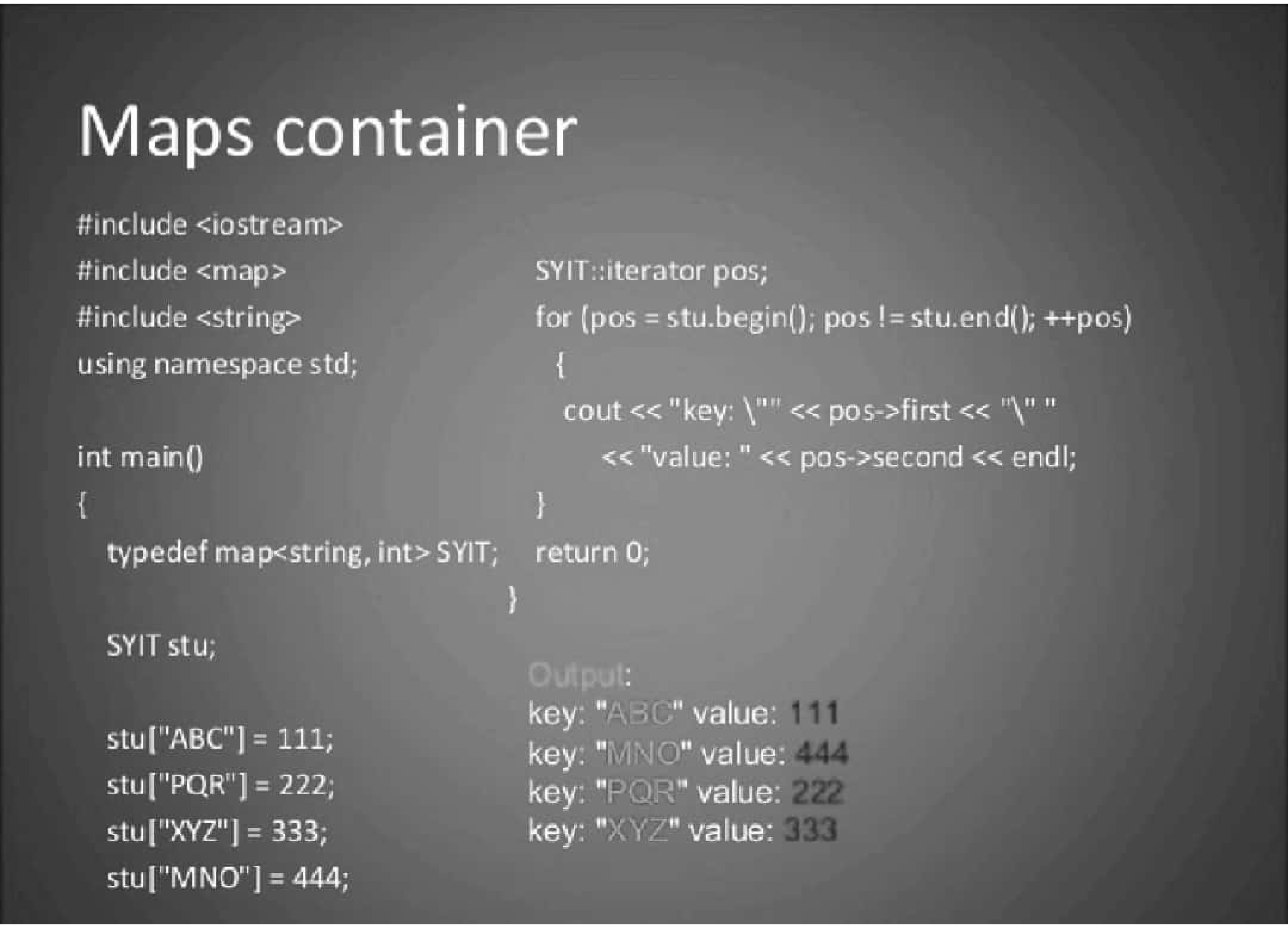

Maps container

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

int main()
{
   typedef map<string, int> SYIT;

   SYIT stu;

   stu["ABC"] = 111;
   stu["PQR"] = 222;
   stu["XYZ"] = 333;
   stu["MNO"] = 444;

   SYIT::iterator pos;
   for (pos = stu.begin(); pos != stu.end(); ++pos)
     {
      cout << "key: \"" << pos->first << "\" "
           << "value: " << pos->second << endl;
     }
   return 0;
}
```

Output:

```
key: "ABC" value: 111
key: "MNO" value: 444
key: "PQR" value: 222
key: "XYZ" value: 333
```

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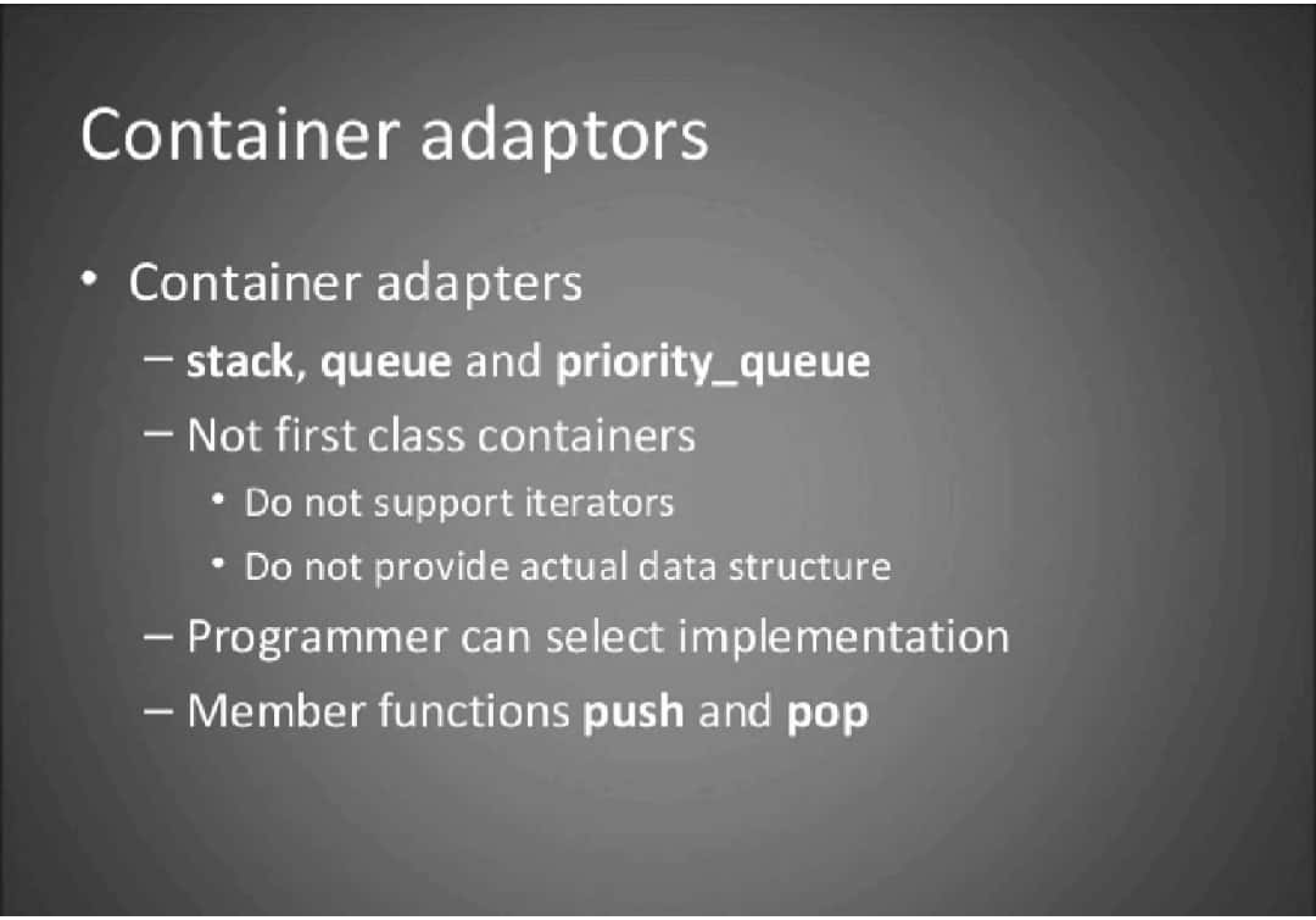

Container adaptors

- Container adapters
  - **stack, queue** and **priority_queue**
  - Not first class containers
    - Do not support iterators
    - Do not provide actual data structure
  - Programmer can select implementation
  - Member functions **push** and **pop**

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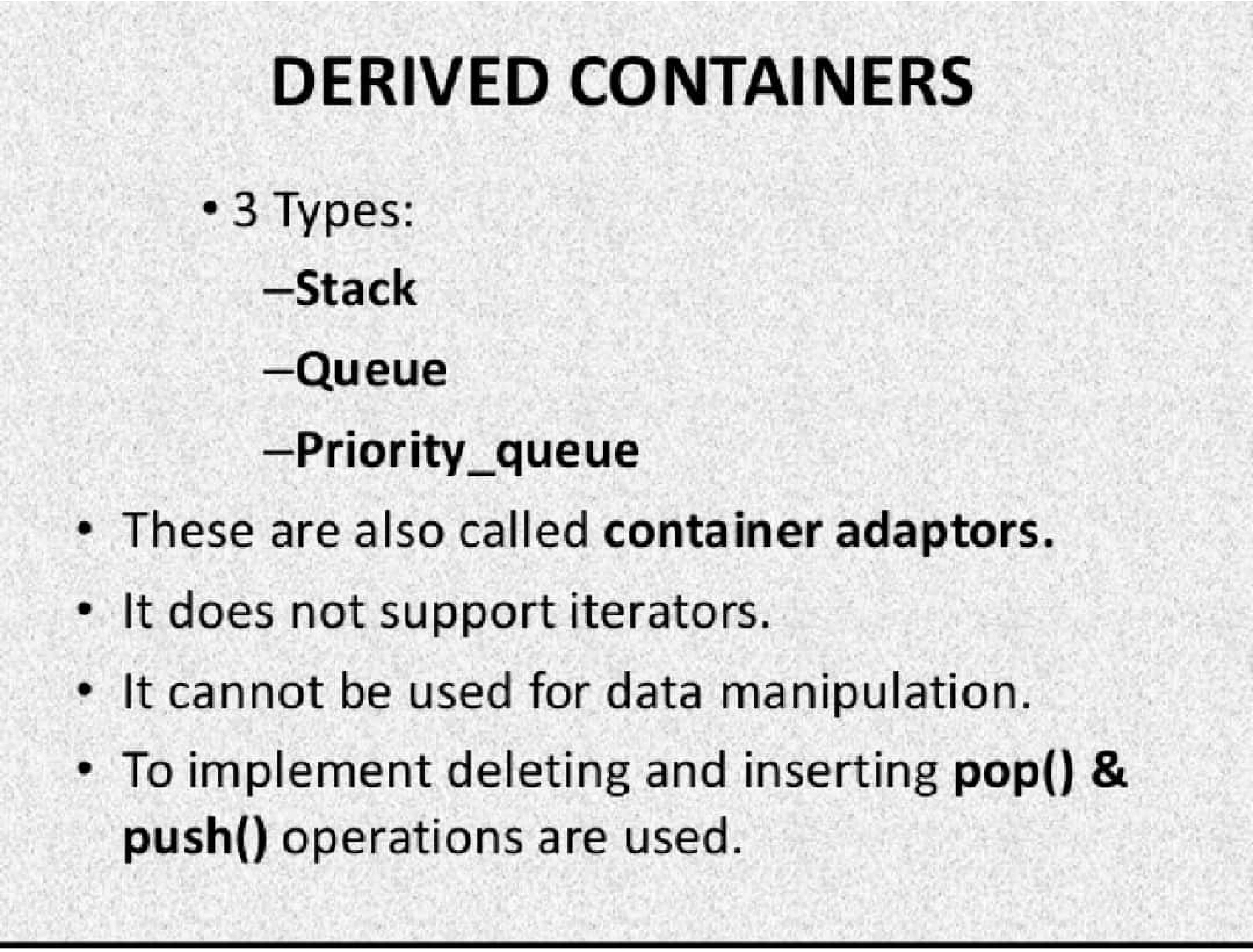

DERIVED CONTAINERS

- 3 Types:
  - –**Stack**
  - –**Queue**
  - –**Priority_queue**
- These are also called **container adaptors.**
- It does not support iterators.
- It cannot be used for data manipulation.
- To implement deleting and inserting **pop() & push()** operations are used.

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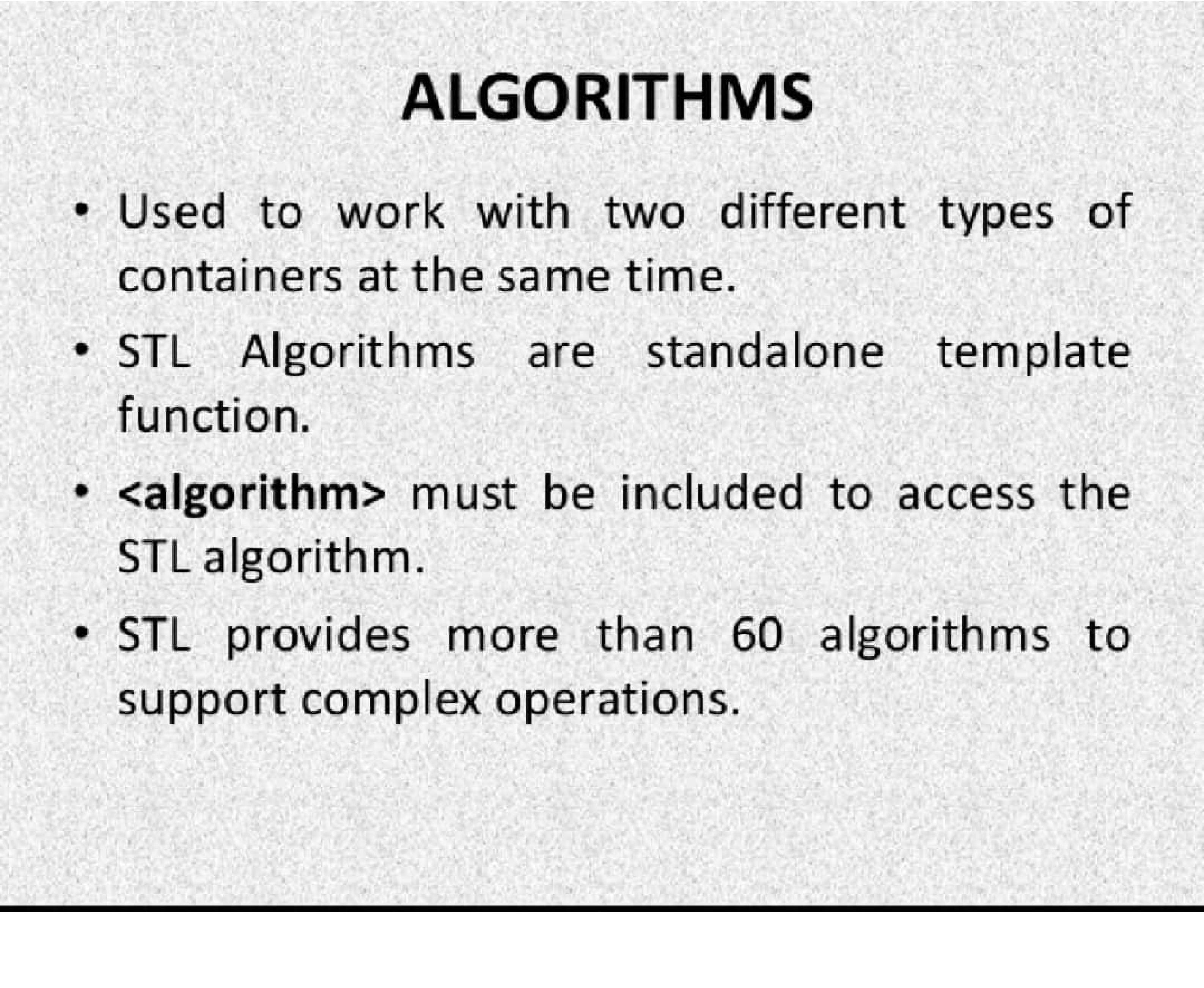

ALGORITHMS

- Used to work with two different types of containers at the same time.
- STL Algorithms are standalone template function.
- **<algorithm>** must be included to access the STL algorithm.
- STL provides more than 60 algorithms to support complex operations.

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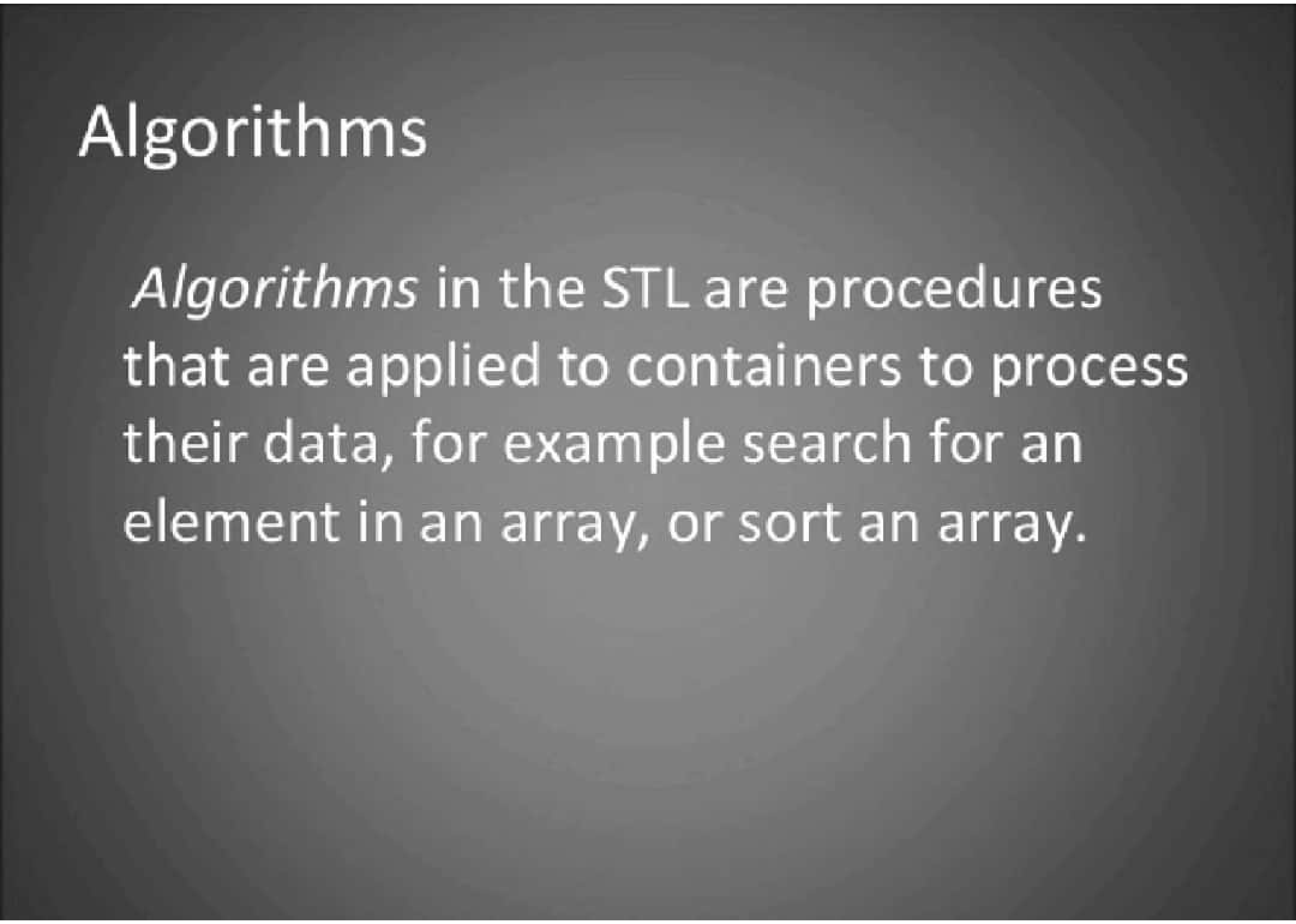

Algorithms

Algorithms in the STL are procedures that are applied to containers to process their data, for example search for an element in an array, or sort an array.

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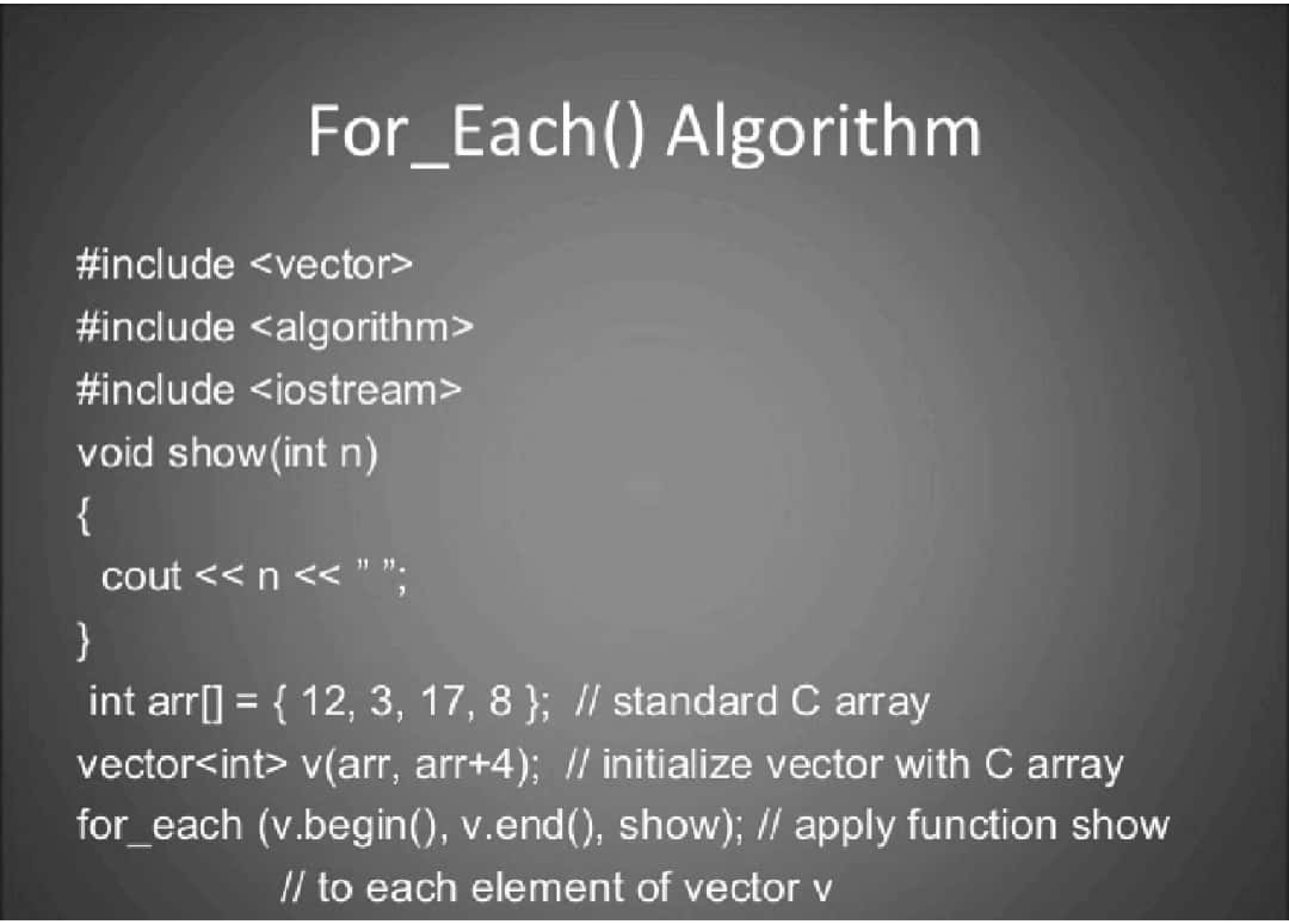

For_Each() Algorithm

```
#include <vector>
#include <algorithm>
#include <iostream>
void show(int n)
{
  cout << n << " ";
}
 int arr[] = { 12, 3, 17, 8 };  // standard C array
vector<int> v(arr, arr+4);  // initialize vector with C array
for_each (v.begin(), v.end(), show); // apply function show
                // to each element of vector v
```

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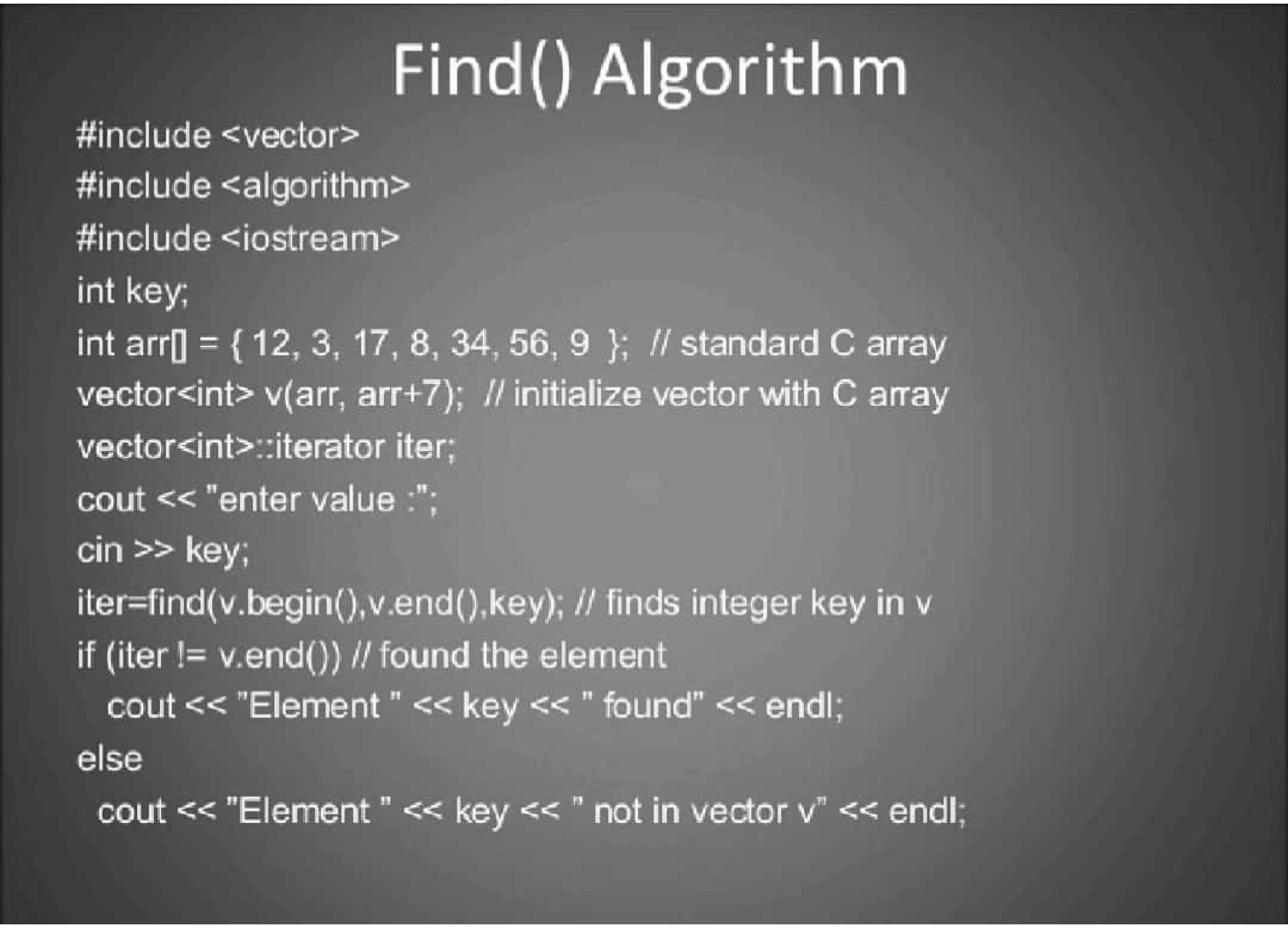

Find() Algorithm

```
#include <vector>
#include <algorithm>
#include <iostream>
int key;
int arr[] = { 12, 3, 17, 8, 34, 56, 9  };  // standard C array
vector<int> v(arr, arr+7);  // initialize vector with C array
vector<int>::iterator iter;
cout << "enter value :";
cin >> key;
iter=find(v.begin(),v.end(),key); // finds integer key in v
if (iter != v.end()) // found the element
   cout << "Element " << key << " found" << endl;
else
  cout << "Element " << key << " not in vector v" << endl;
```

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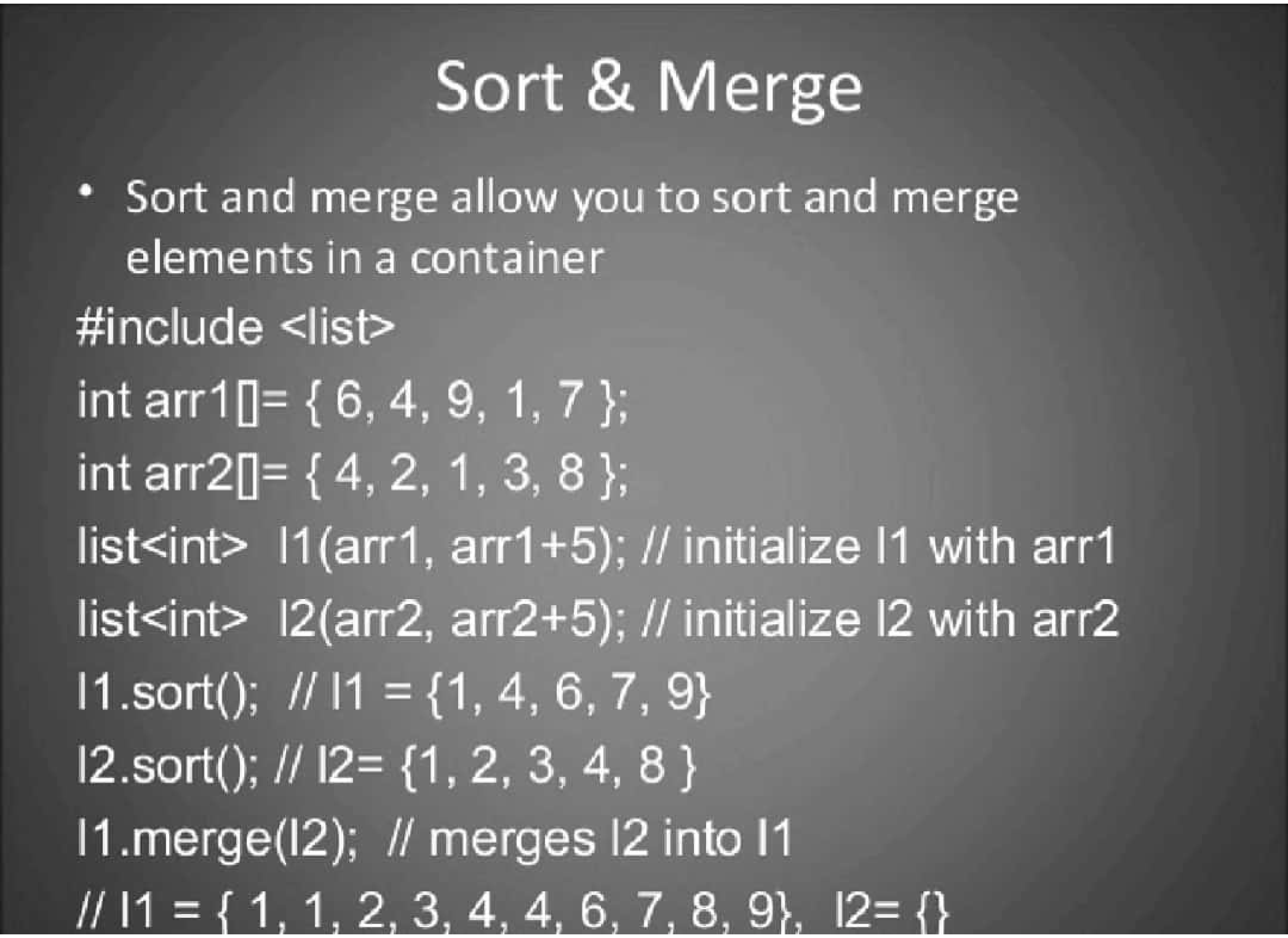

Sort & Merge

- Sort and merge allow you to sort and merge elements in a container

```
#include <list>
int arr1[]= { 6, 4, 9, 1, 7 };
int arr2[]= { 4, 2, 1, 3, 8 };
list<int>  l1(arr1, arr1+5); // initialize l1 with arr1
list<int>  l2(arr2, arr2+5); // initialize l2 with arr2
l1.sort();  // l1 = {1, 4, 6, 7, 9}
l2.sort(); // l2= {1, 2, 3, 4, 8 }
l1.merge(l2);  // merges l2 into l1
// l1 = { 1, 1, 2, 3, 4, 4, 6, 7, 8, 9},  l2= {}
```

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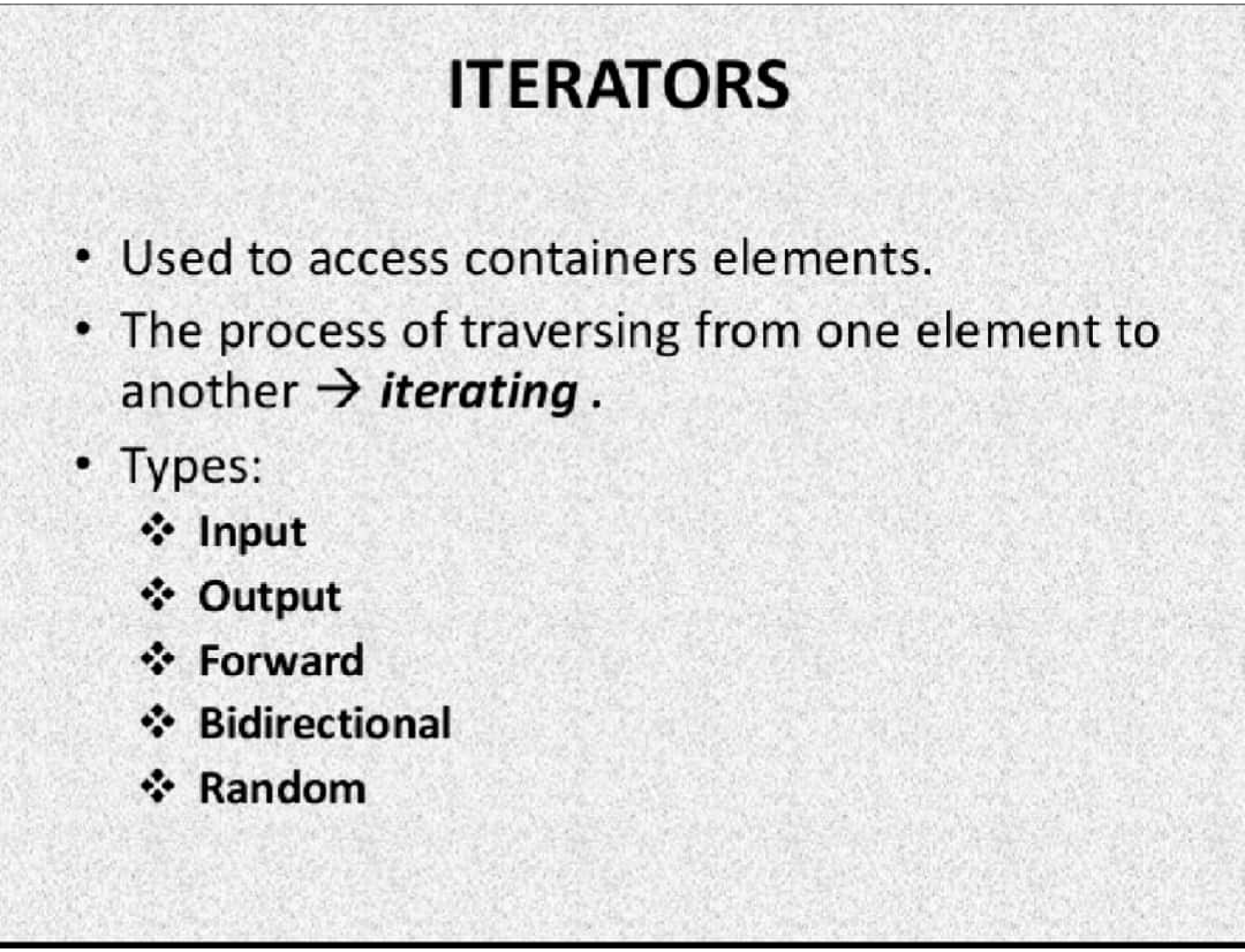

ITERATORS

- Used to access containers elements.
- The process of traversing from one element to another → ***iterating*** **.**
- Types:
  - **Input**
  - **Output**
  - **Forward**
  - **Bidirectional**
  - **Random**

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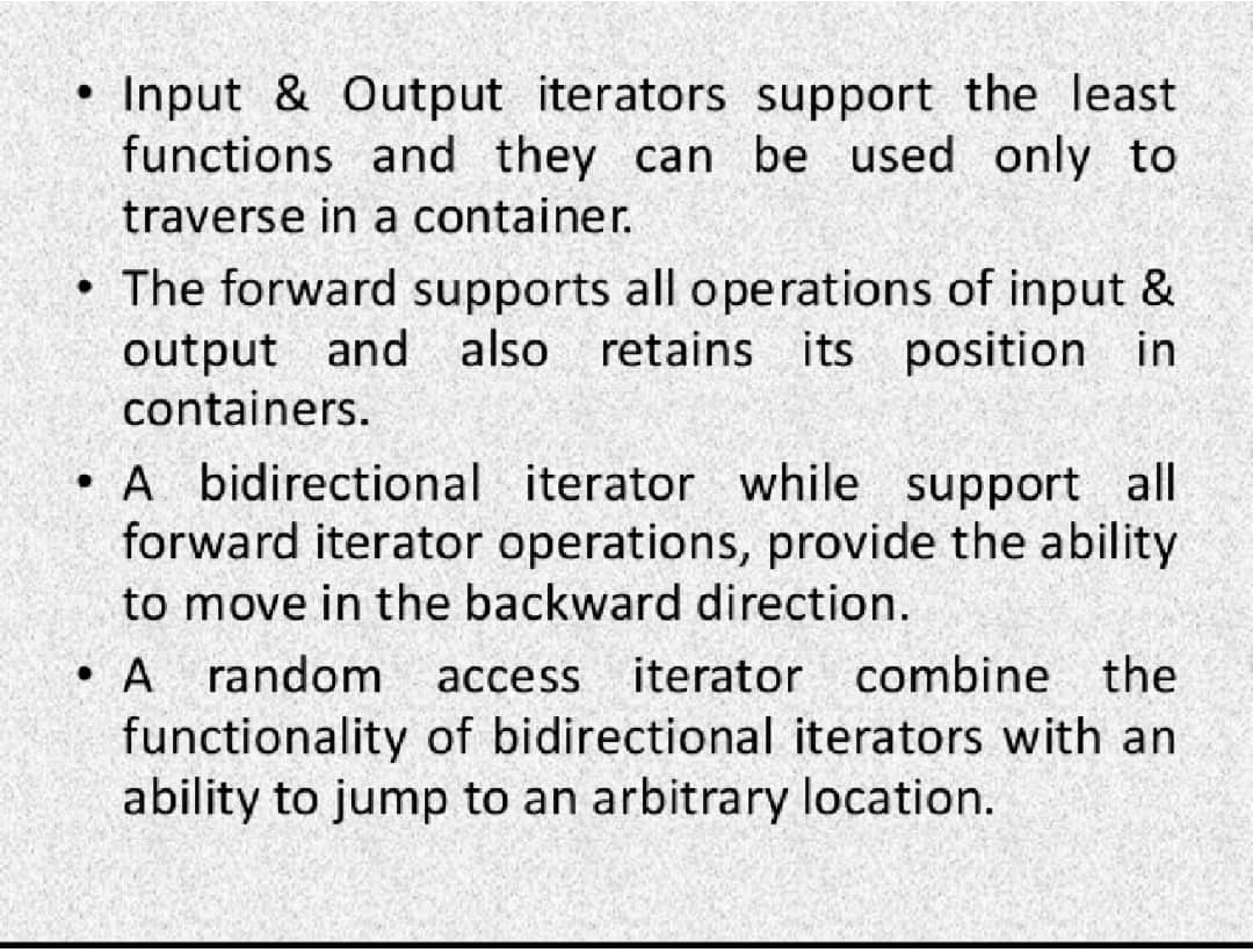

- Input & Output iterators support the least functions and they can be used only to traverse in a container.
- The forward supports all operations of input & output and also retains its position in containers.
- A bidirectional iterator while support all forward iterator operations, provide the ability to move in the backward direction.
- A random access iterator combine the functionality of bidirectional iterators with an ability to jump to an arbitrary location.

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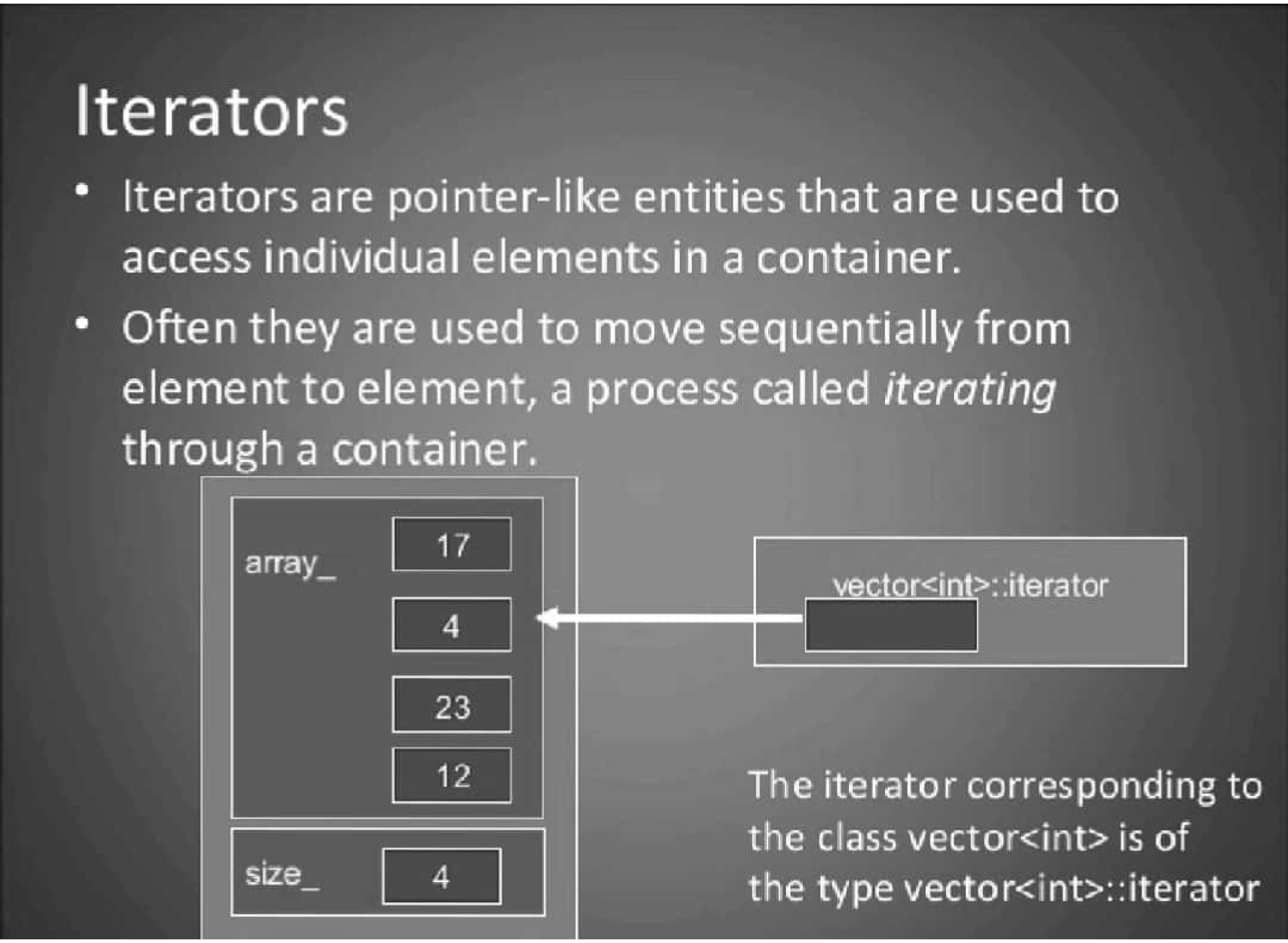

Iterators

- Iterators are pointer-like entities that are used to access individual elements in a container.
- Often they are used to move sequentially from element to element, a process called *iterating* through a container.

The iterator corresponding to the class vector<int> is of the type vector<int>::iterator

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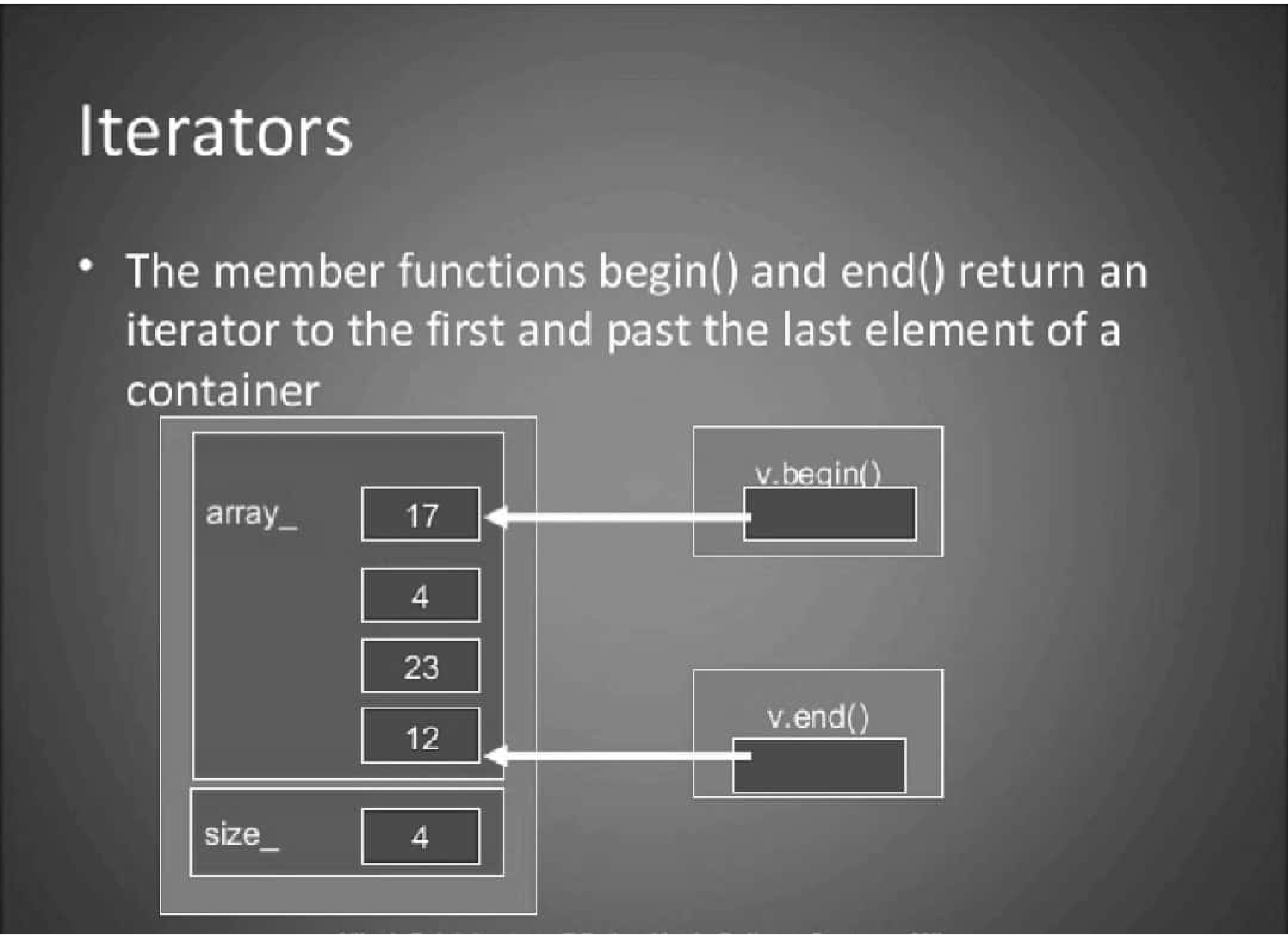

Iterators

- The member functions begin() and end() return an iterator to the first and past the last element of a container

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