Hash Maps

Hash Functions, Values, Associative Containers, and Maps

Contents

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Associative Containers

- Associative Containers are a type of container object that allow us to associate one piece of data to other pieces of data.
  - In a way an array is an Associative Container that associates the data in the array to its index.

- Hash maps are just one type of Associative Container.

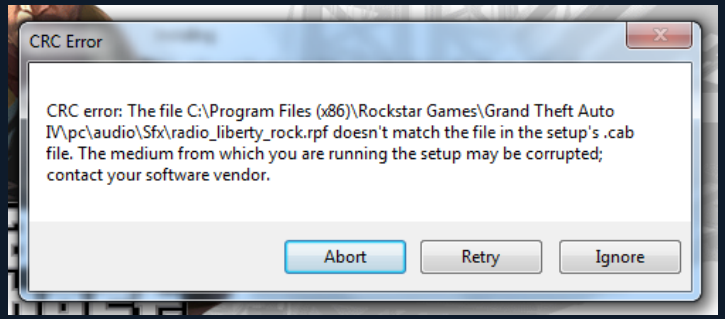
What is Hashing?

- Hashing is a technique that maps an arbitrary amount of data to a value with a fixed length.
  - Often used to map a char array to an int.
  - Example: A name like “John Morgan” might hash to a value like 1043.
- The data is passed into a “hash function” where it is processed and converted into a “hash value”.
- The same input always produces the same output.
  - Hashing “John Morgan” will always produce 1043 (unless the hash function is changed).
- Different input produces different output.
  - Example: “Alex Roberts” hashes to 1163, but “Simon Smith” hashes to 1067.

What is Hashing?

- Often used to compare large amounts of data.
  - E.g. It's faster to compare two integers than two char arrays, although hashing itself is expensive so this is only useful if you're comparing the same strings a lot.

- A similar technique is used to check for data loss in files that have been sent online or copied from a disk, this is called a Cyclic Redundancy Check (CRC)



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Hash Functions

- Takes the data in as an argument and returns the hash value.
- There are lots of different hash functions that produce different results.
  - This is a very simple example, there are much better ones out there.

```
FUNCTION HashString(string_to_hash)
    hash = 0
    FOR each character in the string_to_hash
        Add the character to hash
    END FOR
    RETURN hash
END FUNCTION
```

Hash Maps

- Hash maps (or hash tables) are a type of container that stores two associated pieces of data as a "pair".
  - For example it might store a person's name and address.
- One of the two pieces of data is commonly called the "value".
  - This is the data we might need to retrieve later, e.g. their address.
- The other is usually referred to as the "key".
  - This is used to retrieve the value, e.g. their name.
- To get the value, we hash the key and use the result as an index into an array stored inside the hash map.

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Pair Class

- A Pair class will need:
  - A constructor that takes in a value and its key and stores them both.
  - A method to return the key.
  - A method to return the value.

```
class Pair
{
public:
    Pair(char* a_key, char* a_value);
    ~Pair();

    // Returns the Pair's key.
    const char* GetKey() const;

    // Returns the Pair's Value.
    const char* GetValue() const;

private:
    Pair(const Pair &obj);

    char* m_key;
    char* m_value;
};
```

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Back to Hash Maps

- A hash map can store its data in an array.
- A hash map will need functions to:
  - Add a new value.
  - Get a value by its key.
- Optionally it might have ways to hash and store different types of data and methods to iterate through the map.

Adding to a Hash Map

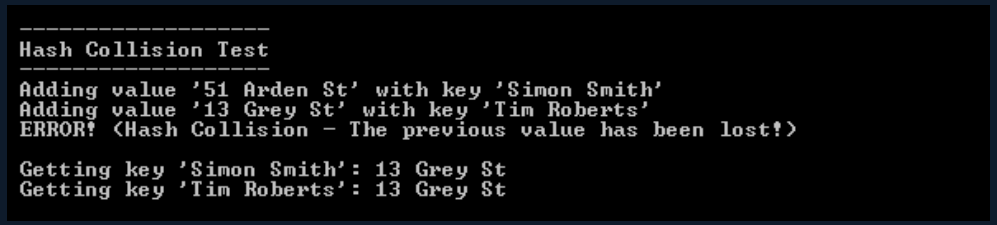
- Hash the key to get an integer.
- Use the hash to calculate an index into the map:
  - unsigned int index = (hash % MAP_SIZE);
- Create a new Pair containing the value and key and store it at the index:
  - m_map[index] = new Pair(key, value);

Getting values from a Hash Map

- Getting a value back out of the table is similar:
- Hash the key to get an integer.
- Use the hash to calculate the index in the map where the value is stored:
  - unsigned int index = (hash % MAP_SIZE);
- Return the value:
  - return m_map[index]->GetValue();

Caveat - Hash Collisions

- The big disadvantage to hash maps is that sometimes different values hash to the same key. This is called a “Collision”.



- When a hash collision occurs, both keys will map to the same index within the table and one will overwrite the other.
  - Good hashing functions will create fewer collisions.
  - One solution is to put the colliding value in the next available index, this is called “open addressing”.

Summary

- Hash maps are good for storing a large number of strings or other data with arbitrary sizes.
  - For example storing names or addresses.
  - Especially useful in games with a lot of dialogue or text.

```
--------------------
Hash Table Test
--------------------
Adding value '16 Collins St' with key 'John Morgan'
Adding value '3 Albert Rd' with key 'Alex Roberts'
Adding value '3/21 Green Ave' with key 'Margaret Adams'

Getting key 'John Morgan': 16 Collins St
Getting key 'Alex Roberts': 3 Albert Rd
Getting key 'Margaret Adams': 3/21 Green Ave
```

References

- Eric Suh . *Hash Tables at cprogramming.com*
  - http://www.cprogramming.com/tutorial/computerscienctheory/hash-table.html

- More hash functions:
  - http://www.cse.yorku.ca/~oz/hash.html

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