CPSC 535 - ADVANCED ALGORITHMS PROJECT 2

Using NIC addresses to Cluster Nodes of a Sensor Network

REPORT

Team Members

Shivangi Shakya

Nicholas Bidler

Saoni Mustafi

Prof. Doina Bein

California State University Fullerton

800 N State College Blvd, Fullerton, CA 92831

Summary

This report contains information about the work done to solve the “Using NIC addresses to Cluster Nodes of a Sensor Network” problem. The inputs are text inputs or a text file with some number of 6-digit hexadecimal numbers, representing a number of NIC addresses in a sensor network. When the hash table for the input values at a given digit location is given an input such that there is a collision of one or more items, ‘chaining’ is used to handle the collision. The objective here is to find an algorithm that minimizes the difference in distance between these chains.

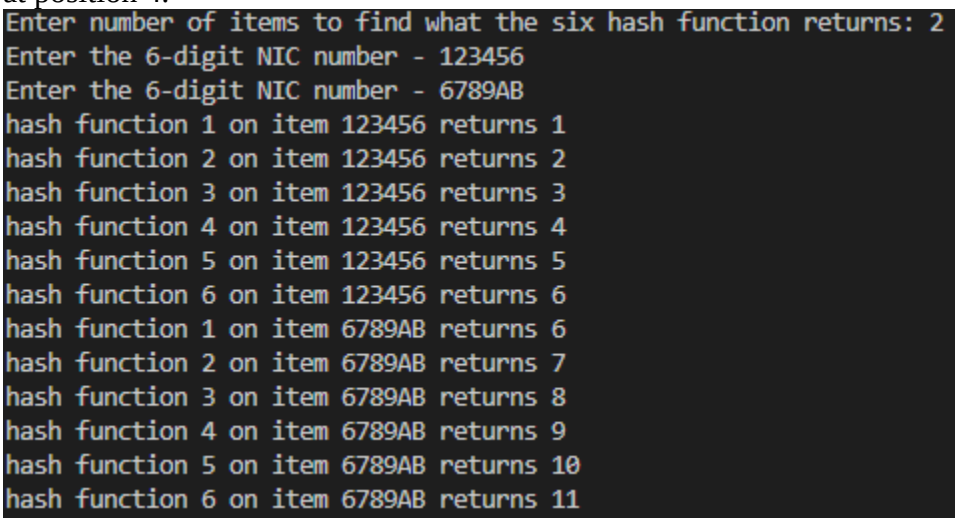
Essentially, the objective is to find an algorithm that functions similarly to a Bucket Sort, such that when inputs are evenly distributed in a hash table with chaining, any non-insertion operations have an average O(n) time class.

The first thing the program does is to initialize one ItemCollection object for each network: each ItemCollection will hold all the HashTables and member functions for its assigned network.

Demonstration:

Example 1: demonstrating that the program output for hashed inputs and outputs is the same as the sample outputs:

Shown in the screenshots below, the example calls a function that returns the decimal value of the hex digit at the appropriate location, i.e., hashfct4() returns the decimal value of the hex digit at position 4.



```
g++ -std=c++17 -Wall SensorCluster.cpp main.cpp -o sensor_tes
./sensor_test
Successfully opened file in1.txt
Successfully opened file in2.txt
Successfully opened file in2.txt
hash function 1 on item 123456 returns 1: passed, score 1/1
hash function 2 on item 123456 returns 2: passed, score 1/1
hash function 3 on item 123456 returns 3: passed, score 1/1
hash function 4 on item 123456 returns 4: passed, score 1/1
hash function 5 on item 123456 returns 5: passed, score 1/1
hash function 6 on item 123456 returns 6: passed, score 1/1
hash function 1 on item 6789AB returns 6: passed, score 1/1
hash function 2 on item 6789AB returns 7: passed, score 1/1
hash function 3 on item 6789AB returns 8: passed, score 1/1
hash function 4 on item 6789AB returns 9: passed, score 1/1
hash function 5 on item 6789AB returns 10: passed, score 1/1
hash function 6 on item 6789AB returns 11: passed, score 1/1
```

Example 2: demonstrating that the program evaluation to find the most even distribution is the same as the sample cases:
After this, the program allows the user to manually enter a network: the number of NICs to be entered, followed by the 6-digit NICs.

```
Network 1
Enter number of items to add to network 1 : 2
Enter the full name of the sensor - 123456
Enter the full name of the sensor - 6789AB
Size is 2 after adding 123456 and 6789AB
BestHashing() for Network 1 ['123456', '6789AB'] returns 1
```

This creates a "network" and runs the BestHashing function, which finds the smallest and largest entry on each hash table, takes the difference of each, and returns the hash table with the smallest difference.

```
Network 2
Successfully opened file in1.txt
New network. Size is 30 after reading in1.txt.
BestHashing() for in1.txt returns 2

Network 3
Successfully opened file in2.txt
New network. Size is 37 after reading in2.txt.
BestHashing() for in2.txt returns 2
```

```
New network. Size is 30 after reading in1.txt: passed, score 1/1
BestHashing() for in1.txt returns 2: passed, score 1/1
New network. Size is 37 after reading in2.txt: passed, score 1/1
BestHashing() for in2.txt returns 2: passed, score 1/1
```

Example 3: showing the network can be interacted with in a way that changes the Best Hashing calculation.

```
Network 4
Enter number of items to remove from network 3 and create a new network: 2
Enter the 6-digit NIC number to remove - 110987
Enter the 6-digit NIC number to remove - 210FED
Successfully opened file in2.txt
New network then read in2.txt
Then remove NICs : 110987 and 210FED. Size becomes 35
BestHashing() after removing 110987 and 210FED returns 3
```

```
Before deletion (result of 2):
|123456 | 234567 | 345678 | 456789 | 56789A | 6789AB | 789ABC
|89ABCD | 9ABCDE | ABCDEF | BCDEF0 | CDEF01 | DEF012 | EF0123
|F01234 | 543210 | 43210F | 3210FE | 210FED | 10FEDC | FEDCBA
|EDCBA9 | DCBA98 | CBA987 | BA9876 | A98765 | 987654 | 876543
|765432 | 654321 | 776543 | 887654 | 998765 | 110987 | 221098
|332109 | 443210

After deletion:
|123456 | 234567 | 345678 | 456789 | 56789A | 6789AB | 789ABC
|89ABCD | 9ABCDE | ABCDEF | BCDEF0 | CDEF01 | DEF012 | EF0123
|F01234 | 543210 | 43210F | 3210FE |        | 10FEDC | FEDCBA
|EDCBA9 | DCBA98 | CBA987 | BA9876 | A98765 | 987654 | 876543
|765432 | 654321 | 776543 | 887654 | 998765 |        | 221098
|332109 | 443210
```

Digit count at positions:

Count of:	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Pos. 1	0	2	2	3	4	2	2	3	3	3	2	2	2	2	2	2
Pos. 2	2	0	3	3	3	2	2	3	3	3	2	2	2	2	2	1
Pos. 3	1	3	2	3	2	2	3	2	3	2	2	2	2	2	1	2
Pos. 4	2	3	3	1	2	3	3	3	2	2	2	2	2	1	2	1
Pos. 5	3	3	2	2	1	3	3	2	2	3	2	2	1	2	1	2
Pos. 6	2	2	2	2	3	2	2	2	3	3	2	1	2	1	2	2

As shown by the above table, position 1 and 2 have a maximum difference of 3, while 3 through 6 have a difference of 2 - as tie-breaker, the first position encountered is the one that is used for the hash table. In this case, the result is position 3, which matches the program's output.

Pseudocode:

Please note that the naming conventions in the real code for the different hash tables is "HashTable[digit][network number]" - so the hash table based on the second digits of the third network would be "HashTable23".

create an *Item* class

initialize the class with *item* dictionary

define a function *itemKeys* and pass the *data* as an argument*:*

identify the *last six digits* as the *key* and the rest part of the data as the *value*
insert into the *item* dictionary
initialize a *key* list and ensure there are no items in this list
insert the *key* in this list
return the *key* of the *item* dictionary

create an *ItemCollection* class

initialize all the 24 HashTables as list of lists required for the four networks (6 Hash Tables for each Network)

(Note: there is one function for each of the networks, with identical functions except for the hash table identities called on)

define a function *addItem[network number]* and pass the data as the argument:

create an object of the *Item* class
key = call *itemKeys()* function to identify the key and value for this data
k1 = call *hashfct1()* and pass the *key* of the argument
append this key and value in the appropriate position *k1* of the HashTable1[network number]
k2 = call *hashfct2()* and pass the *key* of the argument
append this key and value in the appropriate position *k2* of the HashTable2[network number]
k3 = call *hashfct3()* and pass the *key* of the argument
append this key and value in the appropriate position *k3* of the HashTable3[network number]
k4 = call *hashfct4()* and pass the *key* of the argument
append this key and value in the appropriate position *k4* of the HashTable4[network number]
k5 = call *hashfct5()* and pass the *key* of the argument
append this key and value in the appropriate position *k5* of the HashTable5[network number]
k6 = call *hashfct6()* and pass the *key* of the argument
append this key and value in the appropriate position *k6* of the HashTable6[network number]

define a *hashfct1* and pass an argument *nic*:

k = first digit of the hexadecimal *nic* and convert to int datatype

return k

define a *hashfct2* and pass an argument *nic*:

k = second digit of the hexadecimal *nic* and convert to int datatype

return k

define a *hashfct3* and pass an argument *nic*:

k = third digit of the hexadecimal *nic* and convert to int datatype

return k

define a *hashfct4* and pass an argument *nic*:

k = fourth digit of the hexadecimal *nic* and convert to int datatype

return k

define a *hashfct5* and pass an argument *nic*:

k = fifth digit of the hexadecimal *nic* and convert to int datatype

return k

define a *hashfct6* and pass an argument *nic*:

k = sixth digit of the hexadecimal *nic* and convert to int datatype

return k

define a *removeItem()* that takes a list of items to remove *remlist[]* as argument:

call *readText("in2.txt")* to read the network where we need to remove items

for every nic in remlist:

key1 = call *hashfct1(nic)* to compute the hashvalue

for every item in the list HashTable14[key1]:

if *nic* matches with the key to be deleted:

del the key and value and break from the loop

remove the empty dictionary formed by the delete operation

key2 = call *hashfct2(nic)* to compute the hashvalue

for every item in the list HashTable24[key1]:

if *nic* matches with the key to be deleted:

del the key and value and break from the loop

remove the empty dictionary formed by the delete operation

key3 = call *hashfct3(nic)* to compute the hashvalue

for every item in the list HashTable34[key1]:

if *nic* matches with the key to be deleted:

del the key and value and break from the loop

remove the empty dictionary formed by the delete operation

key4 = call *hashfct4(nic)* to compute the hashvalue

for every item in the list HashTable44[key1]:

if *nic* matches with the key to be deleted:

del the key and value and break from the loop

remove the empty dictionary formed by the delete operation

key5 = call *hashfct5(nic)* to compute the hashvalue

for every item in the list HashTable54[key1]:

if *nic* matches with the key to be deleted:
del the key and value and break from the loop
remove the empty dictionary formed by the delete operation

key6 = call *hashfct6(nic)* to compute the hashvalue
for every item in the list HashTable64[key1]:
if *nic* matches with the key to be deleted:
del the key and value and break from the loop
remove the empty dictionary formed by the delete operation

(Note: there is one function for each of the networks, with identical functions except for the hash table identities called on)

define function *bestHashing[network number]()* which takes the network number as argument:

initialize an empty *dict{}* and set *j* = 1
Run a for loop for all tables in HashTable1[network number], HashTable2[network number], HashTable3[network number], HashTable4[network number], HashTable5[network number], HashTable6[network number]:
set *maxcount* = 0 and *mincount* = sys.maxsize
for items in the list of the table:
count = length of that list
if the *count* is less than the *mincount*, update *mincount*
if *count* is greater than the *maxcount*, update *maxcount*.
set *diff* as difference between *maxcount* & *mincount*
insert the *diff* as value and *j* as key in the *dict{}*
increment *j* by 1
determine the *key* with minimum value in the *dict{}*
return the key

define function *readText* and pass the f*ilename* as an argument:

initilalize *list = []*
if the *filename* is *"in1.txt":*
clear *list*
fl = open the file in readmode
print “Successfully opened in1.txt”
datainput = read the content of the file
datainput = update the list of data read delimited as new line
close the file
for every value in the *datainput*:
append it in the *list[]*
for every *l* in *list*:
call addItem2(*l*) to add ‘*l*’ to the table for Network 2
size of the network is the length of the *list[]* after reading in1.txt
print size of network and the file name

if the *filename* is *"in2.txt":*

clear list
fl = open the file in readmode
print “Successfully opened in2.txt”
datainput = read the content of the file
datainput = update the list of data read delimited as new line
close the file
for every value in the *datainput*:
append it in the *list[]*
for every *l* in *list:*
call *addItem3(l)* to add items to the table for Network 3
size of the Network is the length of the *list[]* after reading in2.txt
print size of Network 3 and the file name
for every *l* in *list:*
call *addItem4(l)* to add items to the table for Network 4
return filename and size

inside the *main()* function

create four objects of *ItemCollection* class for the four networks – *item1* for Network 1, *item2* for Network 2, *item3* for Network 3 and *item4* for Network 4
initialize *itemsfind = []*
num1 = The number of items to find what the six hashfct() methods return
enter ‘*num1’* NICs to find the returned hash value and append these to itemsfind
for every *nic* in *itemsfind*:
k1 = call *hashfct1()*
print the hash value returned
k2 = call *hashfct2()*
print the hash value returned
k3 = call *hashfct3()*
print the hash value returned
k4 = call *hashfct4()*
print hash value returned
k5 = call *hashfct5()*
print the hash value returned
k6 = call *hashfct6()*
print the hash value returned

print 'Network 1'
initialize *itemsadd = []*
set *num2* = The number of records to add to form Network 1
Enter *num2* names of sensors to add and append to itemsadd[]
for every *item* in *itemsadd*:
Call the *addItem1()* to add the items individually to the network
print the number of elements in the network
Call the *bestHashing(1)* method for Network 1
Print the table which is the most balanced cluster for Network 1

print 'Network 2'
call the *readText()* through item2 object to read the sensors in file *"in1.txt"* and form Network 2
call the *bestHashing(2)* method for Network 2
print the table which is the most balanced cluster for Network 2

print 'Network 3'
call the *readText()* through *item3* object to read the sensors in file *"in2.txt"* and form Network 2
call the *bestHashing(3)* method for Network 3
print the table which is the most balanced cluster for Network 3

print 'Network 4'
initialize *itemsremove = []*
set *num4* = The number of NICs user wants to remove from Network 3
enter *'num4'* number of NICs to remove and append them to *itemsremove[]*
call the *removeItem()* and pass *itemsremove[]* in the argument
call *bestHashing(4)* method for Network 4 and print the most balanced table

Instructions to run the Code:

The code has been implemented in Python. The name of the file is *'advanceAlgoProj2finalv1.py'*.

The two input files are located in the same directory as "*in1.txt*" and "*in2.txt*".

1. Save the advanceAlgoProj2finalv1.py, in1.txt, and in2.txt in your desired location.
2. In the terminal, change the directory to the folder where you have saved these files using the command *cd <pathname>*.
3. Type *'python3 advanceAlgoProj2finalv1.py'.*
4. Enter the number of items you want to test the hash function on for correctness.
    a. Input a corresponding number of 6-digit hexadecimal numbers
    b. The output should display each digit's value at the corresponding location in decimal
5. Enter the number of items to add to a test network
    a. Input a corresponding number of 6-digit hexadecimal numbers
    b. The output should display which digit produces the smallest variance in hash table chain length
6. The program will at this point output its evaluations for the .txt files, which should both be that the second digit is preferred
7. Enter the number of items to remove from the input set from in2.txt
    a. Be sure it is a valid value before submitting, but similar to 4a and 5a, input the appropriate amount of 6-digit hex numbers