Source File: ~/2336/43/lab43.(C|CPP|cpp|c++|cc|cxx|cp)
Input: under control of `main` function
Output: under control of `main` function
Value: 2

The purpose of this assignment is to modify Lab 38. Instead of keeping the buckets as a two-dimensional array of integers with rows subscripted from 0 to 9 and columns subscripted from 0 to $n-1$, where n is the number of values in the array to be sorted, modify the function to maintain the buckets as a ten element `vector` of `queue`s.

The contents of the one-dimensional vector of positive integers that is being sorted should be printed to the standard output device at the conclusion of each gathering pass.

A sample `main` function for testing this function is shown in Figure 1. A sample execution sequence is shown in Figure 2. A second `main` function, similar to the one used for testing the other sort functions, is shown in Figure 3. To use this function, modify your sort function to eliminate the printing of the vector after each of the gathering passes. The execution sequence for this second `main` function is shown in Figure 4. To use the `Makefile` as distributed in class, add a target of `lab43` to `targets2srcfiles`.

```
1   #include <iostream>
2   #include <cstdlib> // contains prototypes for functions srand and rand
3   #include <vector>
4   #include <cmath>
5
6   using namespace std;
7
8   ostream& operator<<(ostream& os, const vector<uint>& v);
9
10  void bucketSort(vector<uint>& v, uint numDigits);
11
12  int main()
13  {
14    uint numDigits, n, shiftValue, scalingFactor, i;
15    vector<uint> v;
16
17    // randomize random number generator using current time
18    srand(time(0));
19
20    cout << "Enter the number of digits in each of the values to be sorted:"
21         << endl;
22    cin >> numDigits;
23
24    cout << "Enter the number of values to be sorted:" << endl;
25    cin >> n;
26
27    shiftValue = uint(pow(10.0, int(numDigits - 1)));
28    scalingFactor = uint(pow(10.0, int(numDigits))) - 1 - shiftValue;
29
```

Figure 1. /usr/local/2336/src/lab43main.C (Part 1 of 2)

```
30    for (i = 0; i < n; ++i)
31      v.push_back(shiftValue + rand() % scalingFactor);
32
33    cout << v << endl;
34    bucketSort(v, numDigits);
35
36    return 0;
37  }
38
39  ostream& operator<<(ostream& os, const vector<uint>& v)
40  {
41    vector<uint>::const_iterator itr;
42
43    os << "vector" << endl << '{' << endl;
44    for (itr = v.begin(); itr < v.end(); ++itr)
45      os << "  [" << itr - v.begin() << "] = " << *itr << endl;
46    os << '}' << endl;
47
48    return os;
49  }
```

Figure 1. /usr/local/2336/src/lab43main.C (Part 2 of 2)

```
 1   newuser@csunix ~> cd 2336
 2   newuser@csunix ~/2336> ./getlab.ksh 43
 3     * Checking to see if a folder exists for Lab 43. . .No
 4     * Creating a folder for Lab 43
 5     * Checking to see if Lab 43 has sample input and output files. . .No
 6     * Checking to see if /usr/local/2336/src/lab43main.C exists. . .Yes
 7     * Copying file /usr/local/2336/src/lab43main.C to folder ./43
 8     * Checking to see if /usr/local/2336/include/lab43.h exists. . .No
 9     * Copying file /usr/local/2336/src/Makefile to folder ./43
10     * Adding a target of lab43 to targets2srcfiles
11     * Touching file ./43/lab43.cpp
12     * Edit file ./43/lab43.cpp in Notepad++
13   newuser@csunix ~/2336> cd 43
14   newuser@csunix ~/2336/43> ls
15   Makefile          lab43.cpp          lab43main.C        lab43main.C.test
16   newuser@csunix ~/2336/43> make lab43
17   g++ -g -Wall -std=c++11 -c lab43main.C -I/usr/local/2336/include -I.
18   g++ -g -Wall -std=c++11 -c lab43.cpp -I/usr/local/2336/include -I.
19   g++ -o lab43 lab43main.o lab43.o -L/usr/local/2336/lib -lm -lbits
20   newuser@csunix ~/2336/43> ./lab43
21   Enter the number of digits in each of the values to be sorted:
22   3
23   Enter the number of values to be sorted:
24   10
```

```
25   vector          39   vector          53   vector          67   vector
26   {               40   {               54   {               68   {
27     [0] = 481      41     [0] = 250      55     [0] = 309      69     [0] = 136
28     [1] = 778      42     [1] = 481      56     [1] = 136      70     [1] = 189
29     [2] = 189      43     [2] = 682      57     [2] = 943      71     [2] = 250
30     [3] = 943      44     [3] = 943      58     [3] = 648      72     [3] = 309
31     [4] = 682      45     [4] = 136      59     [4] = 449      73     [4] = 449
32     [5] = 136      46     [5] = 778      60     [5] = 250      74     [5] = 481
33     [6] = 309      47     [6] = 648      61     [6] = 778      75     [6] = 648
34     [7] = 648      48     [7] = 189      62     [7] = 481      76     [7] = 682
35     [8] = 250      49     [8] = 309      63     [8] = 682      77     [8] = 778
36     [9] = 449      50     [9] = 449      64     [9] = 189      78     [9] = 943
37   }               51   }               65   }               79   }
38                   52                   66                   80
```

Figure 2. Commands to Compile, Link, & Run Lab 43 (Part 1 of 2)

```
81   newuser@csunix ~/2336/43> ./lab43
82   Enter the number of digits in each of the values to be sorted:
83   4
84   Enter the number of values to be sorted:
85   10
```

```
86   vector        100   vector        114   vector        128   vector        142   vector
87   {             101   {             115   {             129   {             143   {
88     [0] = 4389  102     [0] = 3750  116     [0] = 5617  130     [0] = 7060  144     [0] = 1083
89     [1] = 3881  103     [1] = 7060  117     [1] = 2132  131     [1] = 1083  145     [1] = 2132
90     [2] = 4773  104     [2] = 3240  118     [2] = 3240  132     [2] = 2132  146     [2] = 3240
91     [3] = 3750  105     [3] = 3881  119     [3] = 3750  133     [3] = 3240  147     [3] = 3750
92     [4] = 4567  106     [4] = 2132  120     [4] = 7060  134     [4] = 4389  148     [4] = 3881
93     [5] = 7060  107     [5] = 4773  121     [5] = 4567  135     [5] = 4567  149     [5] = 4389
94     [6] = 1083  108     [6] = 1083  122     [6] = 4773  136     [6] = 5617  150     [6] = 4567
95     [7] = 2132  109     [7] = 4567  123     [7] = 3881  137     [7] = 3750  151     [7] = 4773
96     [8] = 3240  110     [8] = 5617  124     [8] = 1083  138     [8] = 4773  152     [8] = 5617
97     [9] = 5617  111     [9] = 4389  125     [9] = 4389  139     [9] = 3881  153     [9] = 7060
98   }             112   }             126   }             140   }             154   }
99                 113                 127                 141                 155
```

```
156  newuser@csunix ~/2336/43>
```

Figure 2. Commands to Compile, Link, & Run Lab 43 (Part 2 of 2)

```
1   #include <cmath>
2   #include <cstdlib>
3   #include <iostream>
4   #include <vector>
5   #include <algorithm>
6   #include <chrono>
7   #include <random>
8
9   using namespace std;
10
11  void bucketSort(vector<uint>& v, uint numDigits);
12
13  const int N = 1000000;
14  enum TEST_TYPE {RANDOM, ASCENDING, DESCENDING};
15
16  int main()
17  {
18    vector<uint> v, w, x;
19    default_random_engine ran;
20    uniform_int_distribution<> dis; // [1,UINT_MAX]
21    TEST_TYPE testType;
22    int i;
23
24    for (testType = RANDOM;
25         testType <= DESCENDING;
26         testType = static_cast<TEST_TYPE>(testType + 1))
27    {
28      if (!v.empty())
29        v.clear();
30      switch (testType)
31      {
32        case RANDOM:
33          for (i = 0; i < N; ++i)
34            v.push_back(dis(ran));
35          cout << "Random Data:" << endl;
36          break;
37        case ASCENDING:
38          for (i = 0; i < N; ++i)
39            v.push_back(i);
40          cout << "Ascending Data:" << endl;
41          break;
42        case DESCENDING:
43          for (i = 0; i < N; ++i)
44            v.push_back(N - i);
45          cout << "Descending Data:" << endl;
46          break;
47      }
```

Figure 3. `/usr/local/2336/src/lab43main.C.test` (Part 1 of 2)

```
48      x = v;
49      sort(x.begin(), x.end());
50
51      w = v;
52      auto start = chrono::system_clock::now();
53      bucketSort(w, 10);
54      auto stop = chrono::system_clock::now();
55      cout << "Bucket Sort: "
56          << chrono::duration_cast<chrono::milliseconds>(stop-start).count()
57          << "ms" << endl;
58      if (x != w)
59        cout << "Sort didn't work correctly" << endl;
60      cout << endl;
61    }
62  return EXIT_SUCCESS;
63  }
```

Figure 3. `/usr/local/2336/src/lab43main.C.test` (Part 2 of 2)

```
1   newuser@csunix ~/2336/43> mv lab43main.C.test lab43main.C
2   newuser@csunix ~/2336/43> # Edit lab43.cpp to eliminate the printing of
3   newuser@csunix ~/2336/43> # the vector after each of the gathering passes
4   newuser@csunix ~/2336/43> make lab43
5   g++ -g -Wall -std=c++11 -c lab43main.C -I/usr/local/2336/include -I.
6   g++ -g -Wall -std=c++11 -c lab43.cpp -I/usr/local/2336/include -I.
7   g++ -o lab43 lab43main.o lab43.o -L/usr/local/2336/lib -lm -lbits
8   newuser@csunix ~/2336/43> ./lab43
9   Random Data:
10  Bucket Sort: 752ms
11
12  Ascending Data:
13  Bucket Sort: 741ms
14
15  Descending Data:
16  Bucket Sort: 746ms
17
18  newuser@csunix ~/2336/43>
```

Figure 4. Commands to Compile, Link, & Run Lab 43