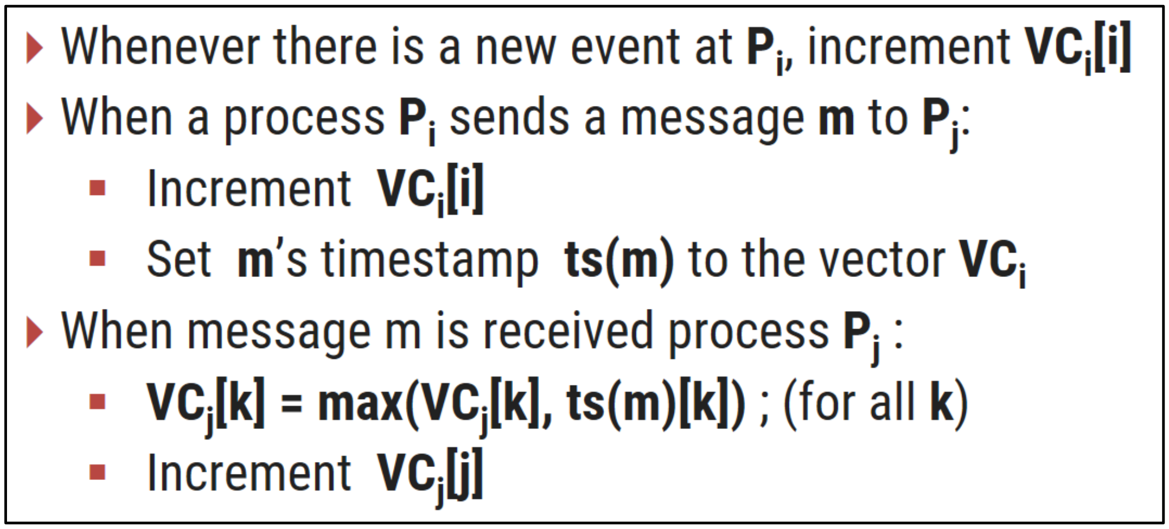
Distributed Systems (CS304)

Assignment - 9

U19CS012

Q.) Implement Vector Clock Algorithm.



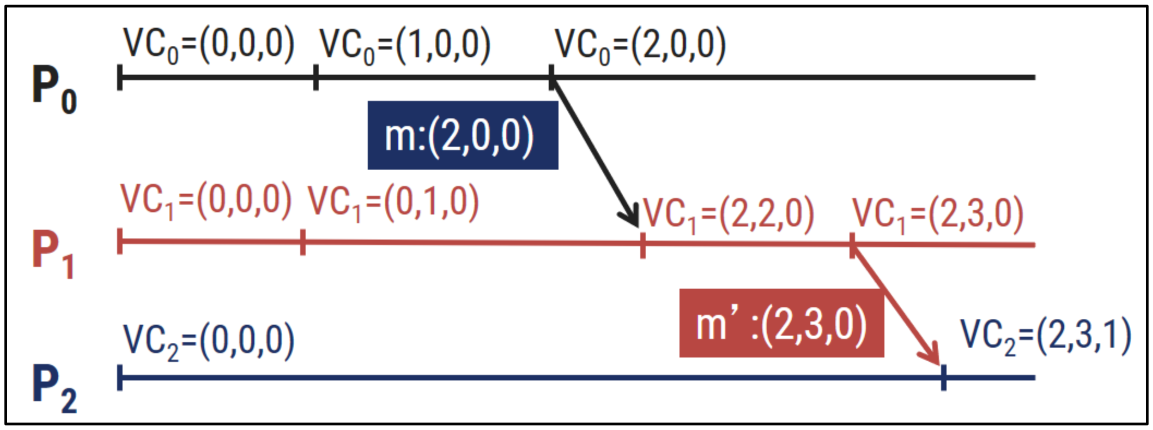
- Whenever there is a new event at **P_i**, increment **$VC_i[i]$**
- When a process **P_i** sends a message **m** to **P_j**:
  - Increment **$VC_i[i]$**
  - Set **m**'s timestamp **ts(m)** to the vector **VC_i**
- When message m is received process **P_j** :
  - **$VC_j[k] = \max(VC_j[k], ts(m)[k])$** ; (for all **k**)
  - Increment **$VC_j[j]$**

Code

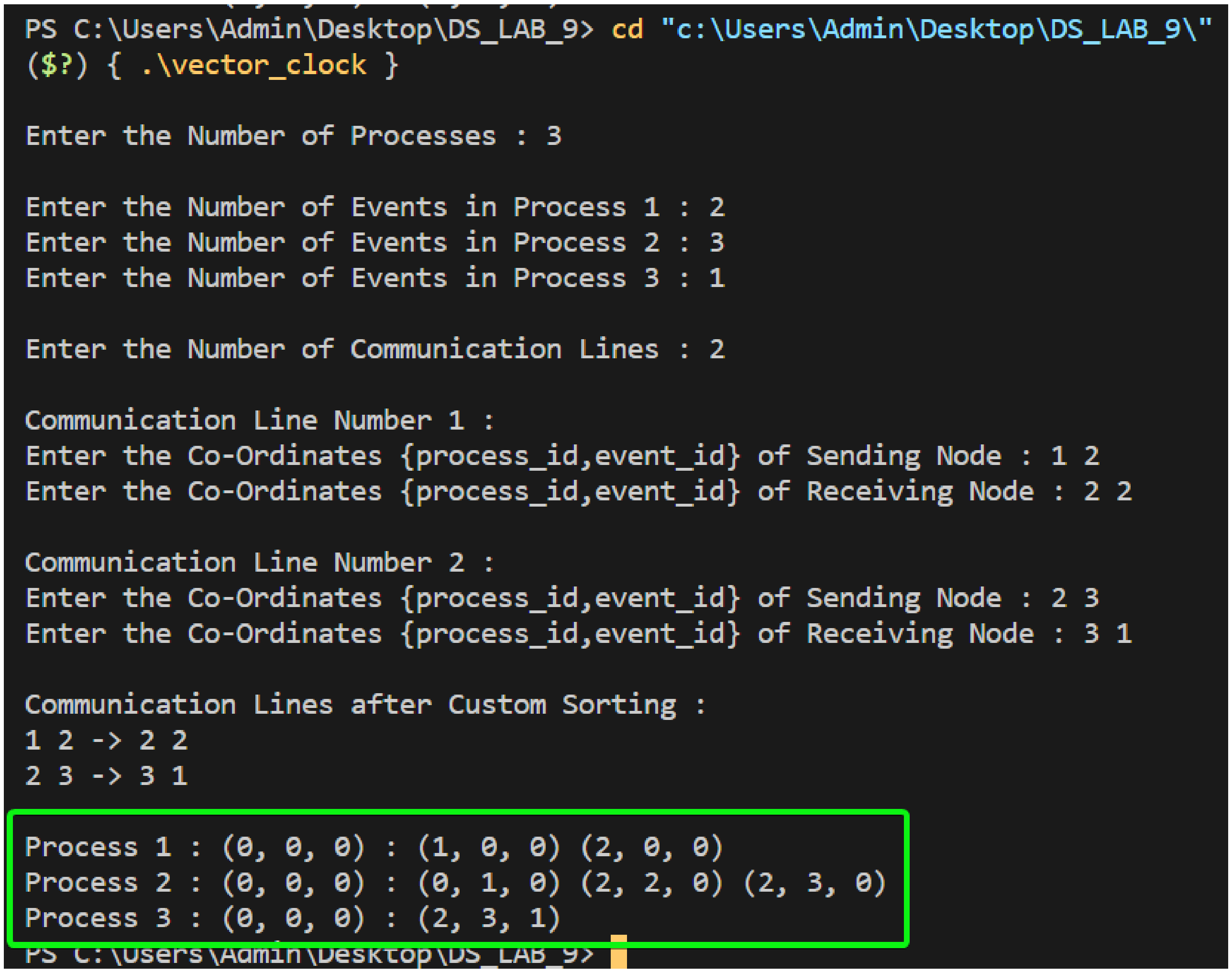
```
// Problem : Implement Vector Clock Algorithm [U19CS012]

#include <bits/stdc++.h>
using namespace std;

typedef vector<int> vi;
typedef pair<int, int> pi;

// Data Structure to Store all the Communication Lines {pid1,eid1} -> {pid2,eid2}
typedef pair<pi, pi> ppipi;

// Custom Comparator Function to Sort all the Communication Lines [Vector Clock]
bool my_sort(ppipi a, ppipi b)
{
    // Sort by Receiving Node {pid,eid} in ascending Order & Sending Node in descending Order
    return ((a.second.second < b.second.second) && (a.second.second < b.first.second) &&
(a.second.first < b.second.second) && (a.second.first < b.first.second) && (a.first.first >
b.first.first));
}

int main()
{
    // freopen("input1.txt", "r", stdin);
    // freopen("input2.txt", "r", stdin);
```

```cpp
    // freopen("input3.txt", "r", stdin);

    // There are n Process namely P1, P2, P3,...PN
    int n;
    cout << "\nEnter the Number of Processes : ";
    cin >> n;
    cout << '\n';

    // Store the Number of Events in Each Process
    vi events(n, 0);
    int max_events = 0;

    for (int pid = 1; pid <= n; pid++)
    {
        int evnts;
        cout << "Enter the Number of Events in Process " << pid << " : ";
        cin >> evnts;

        // Update the Maximum Number of Events
        if (evnts > max_events)
            max_events = evnts;

        events[pid - 1] = evnts;
    }
    cout << '\n';

    // Input the Communication Lines
    int comm_lines;
    cout << "Enter the Number of Communication Lines : ";
    cin >> comm_lines;
    cout << '\n';

    // Data Structure to Store the Communication Lines
    vector<ppipi> lines;

    for (int c = 0; c < comm_lines; c++)
    {
        cout << "Communication Line Number " << c + 1 << " : \n";

        // For Each Communication Line {pid1,i1} -> {pid2,i2}
        int pid1, eid1, pid2, eid2;

        cout << "Enter the Co-Ordinates {process_id,event_id} of Sending Node : ";
        cin >> pid1 >> eid1;
        // Valid Input Checks 1
        assert(pid1 >= 1 && pid1 <= n);
        assert(eid1 >= 1 && eid1 <= events[pid1 - 1]);

        cout << "Enter the Co-Ordinates {process_id,event_id} of Receiving Node : ";
        cin >> pid2 >> eid2;
        // Valid Input Checks 2
        assert(pid2 >= 1 && pid2 <= n);
        assert(eid2 >= 1 && eid2 <= events[pid2 - 1]);

        lines.push_back({{pid1, eid1}, {pid2, eid2}});
        cout << '\n';
    }

    sort(lines.begin(), lines.end(), my_sort);

    // Sorted Communication Lines
    cout << "Communication Lines after Custom Sorting : \n";
    for (int i = 0; i < lines.size(); i++)
    {
        cout << lines[i].first.first << " " << lines[i].first.second << " -> " <<
lines[i].second.first << " " << lines[i].second.second << "\n";
    }
    cout << '\n';

    // Vector Clocks
    vector<vector<vi>> vec(n, vector<vi>(max_events, vi(n, 0)));

    // ? Intialize all the Vector Clock(s) with Rule 1
    for (int i = 0; i < n; i++)
        for (int j = 0; j < events[i]; j++)
            vec[i][j][i] = j + 1;

    // ? Implement Vector Clock Algorithm {Rule 2}
    int p1, e1, t1, p2, e2, t2;
    for (int x = 0; x < comm_lines; x++)
    {
        // Since Zero Based Indexing
        p1 = lines[x].first.first - 1;
        e1 = lines[x].first.second - 1;
        p2 = lines[x].second.first - 1;
        e2 = lines[x].second.second - 1;

        // Update with maximum of all Process in Line of {p1,e1} except the Process itself
        for (int i = 0; i < n; i++)
        {
            if (i != p2)
                vec[p2][e2][i] = max(vec[p2][e2][i], vec[p1][e1][i]);
        }
        e2++;

        // ! [IMP] Update the Following Lines after 'e2' Event, So it Reflects in Other
Process as well
        while (e2 < events[p2])
        {
            for (int i = 0; i < n; i++)
            {
                if (i != p2)
                    vec[p2][e2][i] = vec[p2][e2 - 1][i];
            }
            e2++;
        }
    }

    // Print the Time Stamps of All the Processes
    for (int pid = 0; pid < n; pid++)
    {
        cout << "Process " << pid + 1 << " : ";
        // Intial Vector Clock
        cout << "(";
        for (int k = 0; k < n - 1; k++)
            cout << 0 << ", ";
        cout << 0 << ") : ";

        // Remaining Vector Clocks of Process 'pid'
        for (int eid = 0; eid < events[pid]; eid++)
        {
            cout << "(";
            for (int k = 0; k < n - 1; k++)
                cout << vec[pid][eid][k] << ", ";
            cout << vec[pid][eid][n - 1] << ") ";
        }
        cout << '\n';
    }

    return 0;
}
```

Input (Basic)

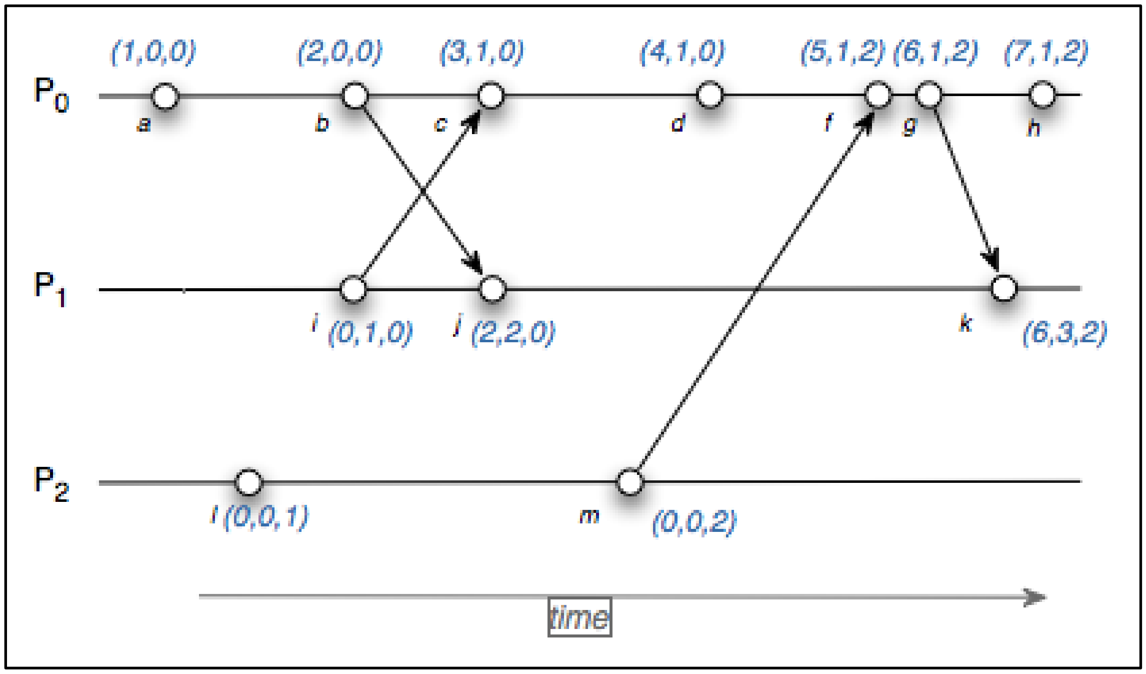


Output

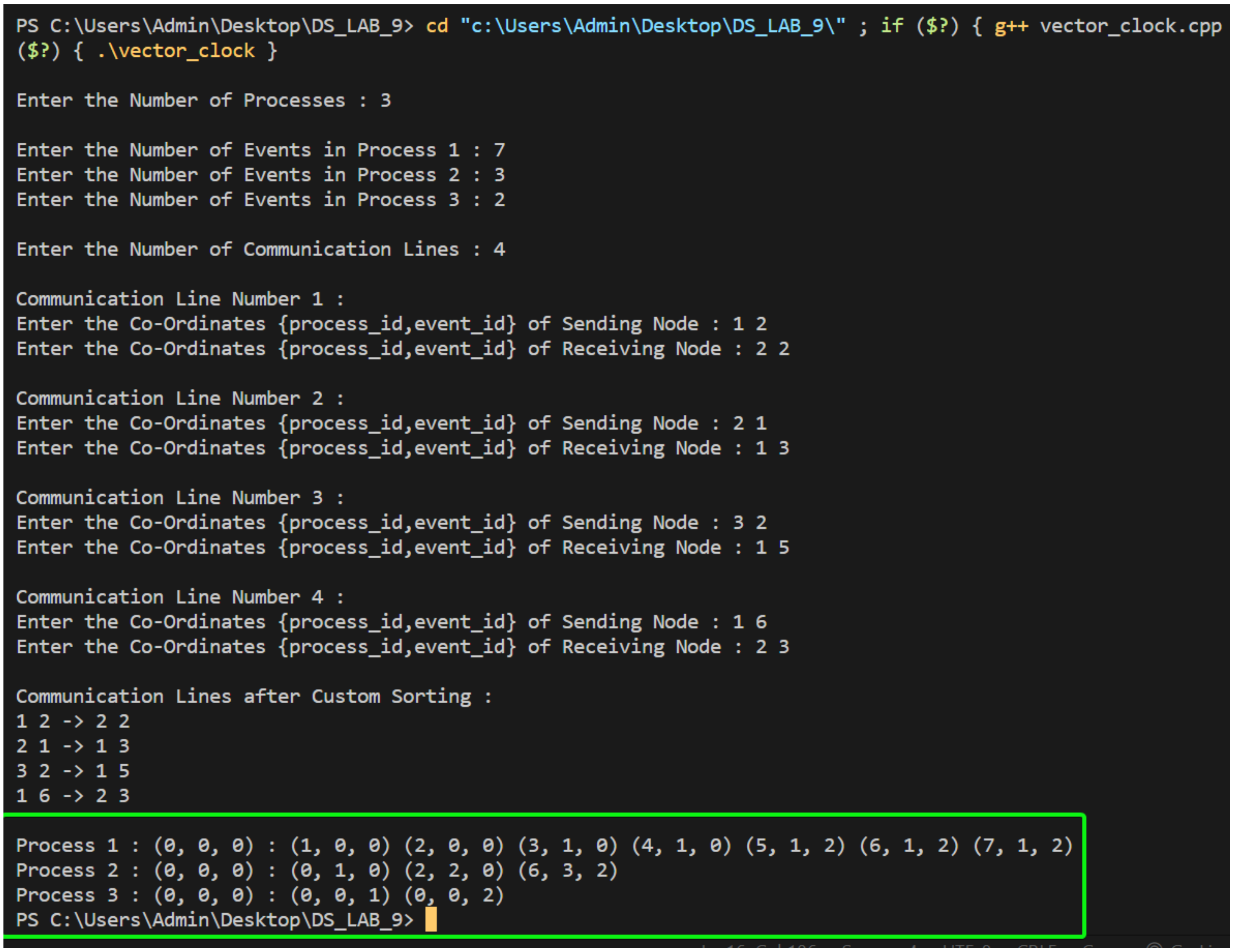


```
PS C:\Users\Admin\Desktop\DS_LAB_9> cd "c:\Users\Admin\Desktop\DS_LAB_9\"
($?) { .\vector_clock }

Enter the Number of Processes : 3

Enter the Number of Events in Process 1 : 2
Enter the Number of Events in Process 2 : 3
Enter the Number of Events in Process 3 : 1

Enter the Number of Communication Lines : 2

Communication Line Number 1 :
Enter the Co-Ordinates {process_id,event_id} of Sending Node : 1 2
Enter the Co-Ordinates {process_id,event_id} of Receiving Node : 2 2

Communication Line Number 2 :
Enter the Co-Ordinates {process_id,event_id} of Sending Node : 2 3
Enter the Co-Ordinates {process_id,event_id} of Receiving Node : 3 1

Communication Lines after Custom Sorting :
1 2 -> 2 2
2 3 -> 3 1

Process 1 : (0, 0, 0) : (1, 0, 0) (2, 0, 0)
Process 2 : (0, 0, 0) : (0, 1, 0) (2, 2, 0) (2, 3, 0)
Process 3 : (0, 0, 0) : (2, 3, 1)
PS C:\Users\Admin\Desktop\DS_LAB_9>
```

Input (Medium)

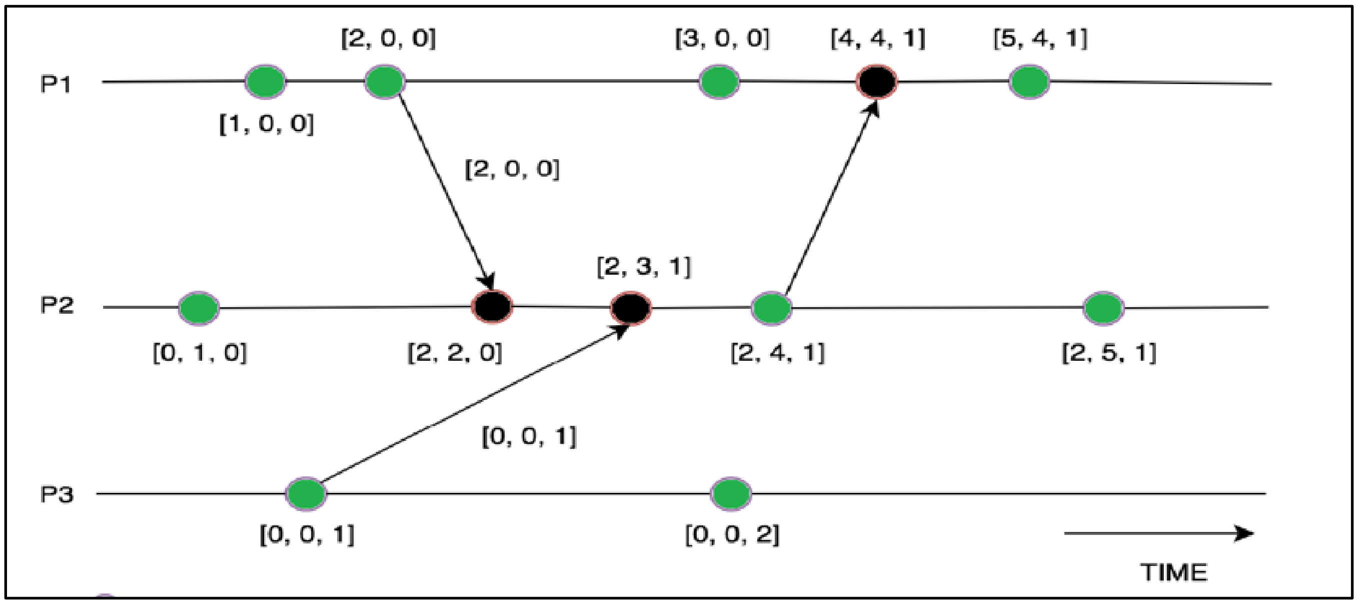


Output

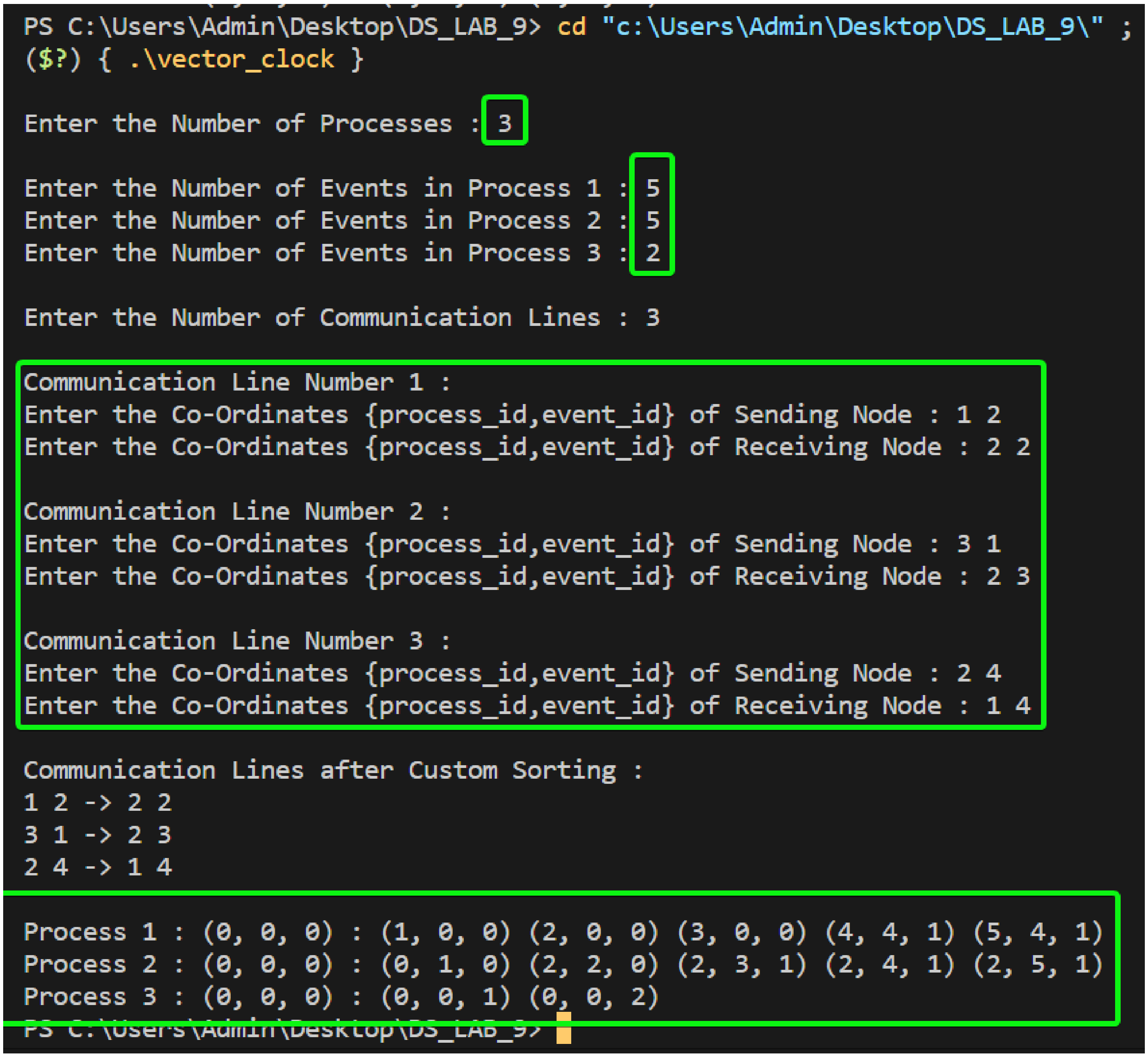


```
PS C:\Users\Admin\Desktop\DS_LAB_9> cd "c:\Users\Admin\Desktop\DS_LAB_9\" ; if ($?) { g++ vector_clock.cpp
($?) { .\vector_clock }

Enter the Number of Processes : 3

Enter the Number of Events in Process 1 : 7
Enter the Number of Events in Process 2 : 3
Enter the Number of Events in Process 3 : 2

Enter the Number of Communication Lines : 4

Communication Line Number 1 :
Enter the Co-Ordinates {process_id,event_id} of Sending Node : 1 2
Enter the Co-Ordinates {process_id,event_id} of Receiving Node : 2 2

Communication Line Number 2 :
Enter the Co-Ordinates {process_id,event_id} of Sending Node : 2 1
Enter the Co-Ordinates {process_id,event_id} of Receiving Node : 1 3

Communication Line Number 3 :
Enter the Co-Ordinates {process_id,event_id} of Sending Node : 3 2
Enter the Co-Ordinates {process_id,event_id} of Receiving Node : 1 5

Communication Line Number 4 :
Enter the Co-Ordinates {process_id,event_id} of Sending Node : 1 6
Enter the Co-Ordinates {process_id,event_id} of Receiving Node : 2 3

Communication Lines after Custom Sorting :
1 2 -> 2 2
2 1 -> 1 3
3 2 -> 1 5
1 6 -> 2 3

Process 1 : (0, 0, 0) : (1, 0, 0) (2, 0, 0) (3, 1, 0) (4, 1, 0) (5, 1, 2) (6, 1, 2) (7, 1, 2)
Process 2 : (0, 0, 0) : (0, 1, 0) (2, 2, 0) (6, 3, 2)
Process 3 : (0, 0, 0) : (0, 0, 1) (0, 0, 2)
PS C:\Users\Admin\Desktop\DS_LAB_9>
```

Input (Hard)



Output



```
PS C:\Users\Admin\Desktop\DS_LAB_9> cd "c:\Users\Admin\Desktop\DS_LAB_9\" ;
($?) { .\vector_clock }

Enter the Number of Processes : 3

Enter the Number of Events in Process 1 : 5
Enter the Number of Events in Process 2 : 5
Enter the Number of Events in Process 3 : 2

Enter the Number of Communication Lines : 3

Communication Line Number 1 :
Enter the Co-Ordinates {process_id,event_id} of Sending Node : 1 2
Enter the Co-Ordinates {process_id,event_id} of Receiving Node : 2 2

Communication Line Number 2 :
Enter the Co-Ordinates {process_id,event_id} of Sending Node : 3 1
Enter the Co-Ordinates {process_id,event_id} of Receiving Node : 2 3

Communication Line Number 3 :
Enter the Co-Ordinates {process_id,event_id} of Sending Node : 2 4
Enter the Co-Ordinates {process_id,event_id} of Receiving Node : 1 4

Communication Lines after Custom Sorting :
1 2 -> 2 2
3 1 -> 2 3
2 4 -> 1 4

Process 1 : (0, 0, 0) : (1, 0, 0) (2, 0, 0) (3, 0, 0) (4, 4, 1) (5, 4, 1)
Process 2 : (0, 0, 0) : (0, 1, 0) (2, 2, 0) (2, 3, 1) (2, 4, 1) (2, 5, 1)
Process 3 : (0, 0, 0) : (0, 0, 1) (0, 0, 2)
PS C:\Users\Admin\Desktop\DS_LAB_9>
```

SUBMITTED BY: U19CS012

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