Project 2: Logical Clock

CSE 531- Distributed Systems

1. Summary

The goal of this project is to implement Lamport's logical clock algorithm upon Project 1. As shown in **Diagram A**, the processes use logical clocks and follow the Lamport's algorithm to coordinate.

Major Tasks

1. Implement logical clock in every customer and branch process
2. Implement Lamport's algorithm for clock coordination among the processes

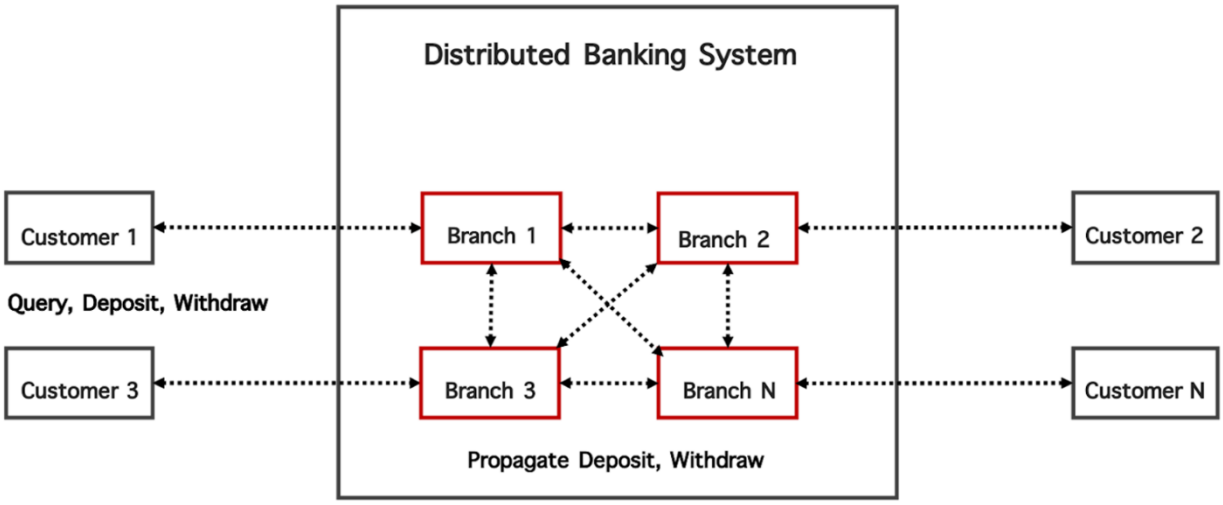

Diagram A: The processes use logical clocks and follow the Lamport's algorithm to coordinate

2. Description

Same as Project 1, customers use Query/Deposit/Withdraw interfaces to issue requests to branches, and branches use Propagate to propagate updates. Every customer Deposit/Withdraw request is handled by one branch which then propagates the update to the other branches.

As illustrated in **Diagram** B, every process maintains its logical lock according to the happens-before relationship between requests 1) of the same process and 2) between send and receive of the same request.

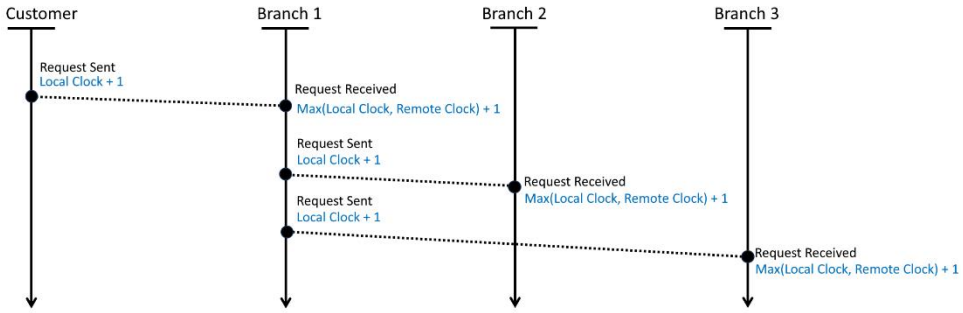

Diagram B: Events triggered by a customer request and their logical times

3. Input and Output

The input file contains a list of Customers and Branch processes. The format of the input file is similar to that of Project 1. Note that the “customer-request-id” parameter in the "events" uniquely identifies every customer request, which needs to be carried over to all the events triggered by this request in order to verify the happens-before relationships are correctly enforced.

```
[ // Start of the Array of Branch and Customer processes
  { // Customer process #1
    "id" : {a unique identifier of a customer},
    "type" : “customer”,
    " customer-requests " :  [{“customer-request-id“: {unique identifier of a customer request} ,
"interface":{deposit | withdraw}, "money": {an integer value} }]
  }
  { … } // Customer process #2
  { … } // Customer process #3
  { … } // Customer process #N
  { // Branch process #1
    "id" : {a unique identifier of a branch},
    “type” : “branch”
    “balance” : {the initial amount of money stored in the branch}
  }
  { … } // Branch process #2
  { … } // Branch process #3
  { … } // Branch process #N
```

```
] // End of the Array of Branch and Customer processes
```

The output will contain three parts: (1) all the events (along with their logical times) taken place on each customer, (2) all the events (along with their logical times) taken place on each branch, and (3) all the events (along with their logical times) triggered by each customer Deposit/Withdraw request. For clarity, order all the events from the same customer/branch/customer-request by their logical times in the output.

```
[ // Start of the Array of Customer processes
  { // Customer process #1
    “id” : {a unique identifier of a customer},
    “type”: “customer”,
    “events”: [{ “customer-request-id”: {unique identifier of the customer request}, “logical time”: {timestamp from the logical clock }} …]
  }
 { … } // Customer process #2
 { … } // Customer process #3
 { … } // Customer process #N
] // End of the Customer processes
```

```
[ // Start of the Array of Branch processes
  { // Branch process #1
    “id” : {a unique identifier of a Branch},
    “type”: “branch”,
    “events”: [{ “customer-request-id”: {a unique identifier of the customer request that triggered this event}, “logical time”: { timestamp from the logical clock }} …]
  }
 { … } // Branch process #2
 { … } // Branch process #3
 { … } // Branch process #N
] // End of the Branch processes
```

```
[ // Start of the Array of events across all processes
  { // Event #1
    “customer-request-id” : {a unique identifier of a customer request}
    “logical time”: [{timestamp from the logical clock } …]
  }
```

```
 { … } // Event #2
 { … } // Event #3
 { … } // Event #N
] // End of the Events
```

Example of the input file

```
[
   {
      "id": 1,
      "type": "customer",
      "customer-requests": [
         {
            " customer-request-id ": 1,
            "interface": "deposit",
            "money": 10
         },
         {
            " customer-request-id": 2,
            "interface": "withdraw",
            "money": 10
         }
      ]
   },
   {
      "id": 2,
      "type": "customer",
      "customer-requests": [
         {
            "customer-request-id ": 3,
            "interface": "deposit",
            "money": 10
         },
         {
            " customer-requests": 4,
            "interface": "withdraw",
            "money": 10
         }
      ]
   },
   {
      "id": 3,
      "type": "customer",
      "customer-requests": [
         {
            " customer-requests": 5,
            "interface": "deposit",
            "money": 10
         },
         {
```

```
            " customer-requests ": 6,
            "interface": "withdraw",
            "money": 10
         }
      ]
   },
   {
      "id": 1,
      "type": "branch",
      "balance": 400
   },
   {
      "id": 2,
      "type": "branch",
      "balance": 400
   },
   {
      "id": 3,
      "type": "branch",
      "balance": 400
   }
]
```


Expected output file:


```
// Part 1: List all the events taken place on each customer
[{
   "id":1,
   "type":"customer",
   "events": [
      {"customer-request-id": 1, "logical_clock": 1, "interface": "deposit", "comment": "event_sent from customer 1"},
      {"customer-request-id": 2, "logical_clock": 2, "interface": "withdraw", "comment": "event_sent from customer
1"}]
},
{
   "id":2,
   "type":"customer",
   "events": [
      {"customer-request-id": 3, "logical_clock": 1, "interface": "deposit", "comment": "event_sent from customer 2"},
      {"customer-request-id": 4, "logical_clock": 2, "interface": "withdraw", "comment": "event_sent from customer
2"}
   ]
},
{
   "id":3,
   "type":"customer",
   "events": [
      {"customer-request-id": 5, "logical_clock": 1, "interface": "deposit", "comment": "event_sent from customer 3"},
      {"customer-request-id": 6, "logical_clock": 2, "interface": "withdraw", "comment": "event_sent from customer
3"}]
```

```
}]

// Part 2: List all the events taken place on each branch
[{
   "id": 1,
   "type": "branch",
   "events":
   [{"customer-request-id": 1, "logical_clock": 2, "interface": "deposit", "comment": "event_recv from customer 1"},
   {"customer-request-id": 1, "logical_clock": 3, "interface": "propogate_deposit", "comment": "event_sent to branch
2"},
   {"customer-request-id": 1, "logical_clock": 4, "interface": "propogate_deposit", "comment": "event_sent to branch
3"},
   {"customer-request-id": 3, "logical_clock": 7, "interface": "propogate_deposit", "comment": "event_recv from
branch 2"},
   {"customer-request-id": 5, "logical_clock": 8, "interface": "propogate_deposit", "comment": "event_recv from
branch 3"},
   {"customer-request-id": 2, "logical_clock": 9, "interface": "withdraw", "comment": "event_recv from customer 1"},
   {"customer-request-id": 2, "logical_clock": 10, "interface": "propogate_withdraw", "comment": "event_sent to
branch 2"},
   {"customer-request-id": 2, "logical_clock": 11, "interface": "propogate_withdraw", "comment": "event_sent to
branch 3"},
   {"customer-request-id": 4, "logical_clock": 14, "interface": "propogate_withdraw", "comment": "event_recv from
branch 2"},
   {"customer-request-id": 6, "logical_clock": 15, "interface": "propogate_withdraw", "comment": "event_recv from
branch 3"}]
},
{
   "id": 2,
   "type": "branch",
   "events":
   [{"customer-request-id": 1, "logical_clock": 4, "interface": "propogate_deposit", "comment": "event_recv from
branch 1"},
   {"customer-request-id": 3, "logical_clock": 5, "interface": "deposit", "comment": "event_recv from customer 2"},
   {"customer-request-id": 3, "logical_clock": 6, "interface": "propogate_deposit", "comment": "event_sent to branch
1"},
   {"customer-request-id": 3, "logical_clock": 7, "interface": "propogate_deposit", "comment": "event_sent to branch
3"},
   {"customer-request-id": 2, "logical_clock": 11, "interface": "propogate_withdraw", "comment": "event_recv from
branch 1"},
   {"customer-request-id": 4, "logical_clock": 12, "interface": "withdraw", "comment": "event_recv from customer 2"},
   {"customer-request-id": 4, "logical_clock": 13, "interface": "propogate_withdraw", "comment": "event_sent to
branch 1"},
   {"customer-request-id": 5, "logical_clock": 14, "interface": "propogate_deposit", "comment": "event_recv from
branch 3"},
   {"customer-request-id": 4, "logical_clock": 15, "interface": "propogate_withdraw", "comment": "event_sent to
branch 3"},
   {"customer-request-id": 6, "logical_clock": 18, "interface": "propogate_withdraw", "comment": "event_recv from
branch 3"}]
},
{
   "id": 3,
   "type": "branch",
   "events":
```

[{"customer-request-id": 5, "logical_clock": 2, "interface": "deposit", "comment": "event_recv from customer 3"},
{"customer-request-id": 5, "logical_clock": 3, "interface": "propogate_deposit", "comment": "event_sent to branch 1"},
{"customer-request-id": 1, "logical_clock": 5, "interface": "propogate_deposit", "comment": "event_recv from branch 1"},
{"customer-request-id": 5, "logical_clock": 6, "interface": "propogate_deposit", "comment": "event_sent to branch 2"},
{"customer-request-id": 3, "logical_clock": 8, "interface": "propogate_deposit", "comment": "event_recv from branch 2"},
{"customer-request-id": 2, "logical_clock": 12, "interface": "propogate_withdraw", "comment": "event_recv from branch 1"},
{"customer-request-id": 6, "logical_clock": 13, "interface": "withdraw", "comment": "event_recv from customer 3"},
{"customer-request-id": 6, "logical_clock": 14, "interface": "propogate_withdraw", "comment": "event_sent to branch 1"},
{"customer-request-id": 4, "logical_clock": 16, "interface": "propogate_withdraw", "comment": "event_recv from branch 2"},
{"customer-request-id": 6, "logical_clock": 17, "interface": "propogate_withdraw", "comment": "event_sent to branch 2"}]

}]

// Part 3: List all the events (along with their logical times) triggered by each customer Deposit/Withdraw request

[{"id": 1,"customer-request-id":1,"type": "customer","logical_clock": 1,"interface": "deposit","comment": "event_sent from customer 1"},

{"id": 1,"customer-request-id":1,"type": "branch","logical_clock": 2,"interface": "deposit","comment": "event_recv from customer 1"},

{"id": 1,"customer-request-id":1,"type": "branch","logical_clock": 3,"interface": "propogate_deposit","comment": "event_sent to branch 2"},

{"id": 2,"customer-request-id":1,"type": "branch","logical_clock": 4,"interface": "propogate_deposit","comment": "event_recv from branch 1"},

{"id": 1,"customer-request-id":1,"type": "branch","logical_clock": 4,"interface": "propogate_deposit","comment": "event_sent to branch 3"},

{"id": 3,"customer-request-id":1,"type": "branch","logical_clock": 5,"interface": "propogate_deposit","comment": "event_recv from branch 1"},

{"id": 1,"customer-request-id":2,"type": "customer","logical_clock": 2,"interface": "withdraw","comment": "event_sent from customer 1"},

{"id": 1,"customer-request-id":2,"type": "branch","logical_clock": 9,"interface": "withdraw","comment": "event_recv from customer 1"},

{"id": 1,"customer-request-id":2,"type": "branch","logical_clock": 10,"interface": "propogate_withdraw","comment": "event_sent to branch 2"},

{"id": 2,"customer-request-id":2,"type": "branch","logical_clock": 11,"interface": "propogate_withdraw","comment": "event_recv from branch 1"},

{"id": 1,"customer-request-id":2,"type": "branch","logical_clock": 11,"interface": "propogate_withdraw","comment":

"event_sent to branch 3"},

{"id": 3,"customer-request-id":2,"type": "branch","logical_clock": 12,"interface": "propogate_withdraw","comment": "event_recv from branch 1"},

{"id": 2,"customer-request-id":3,"type": "customer","logical_clock": 1,"interface": "deposit","comment": "event_sent from customer 2"},

{"id": 2,"customer-request-id":3,"type": "branch","logical_clock": 5,"interface": "deposit","comment": "event_recv from customer 2"},

{"id": 2,"customer-request-id":3,"type": "branch","logical_clock": 6,"interface": "propogate_deposit","comment": "event_sent to branch 1"},

{"id": 2,"customer-request-id":3,"type": "branch","logical_clock": 7,"interface": "propogate_deposit","comment": "event_sent to branch 3"},

{"id": 1,"customer-request-id":3,"type": "branch","logical_clock": 7,"interface": "propogate_deposit","comment": "event_recv from branch 2"},

{"id": 3,"customer-request-id":3,"type": "branch","logical_clock": 8,"interface": "propogate_deposit","comment": "event_recv from branch 2"},

{"id": 2,"customer-request-id":4,"type": "customer","logical_clock": 2,"interface": "withdraw","comment": "event_sent from customer 2"},

{"id": 2,"customer-request-id":4,"type": "branch","logical_clock": 12,"interface": "withdraw","comment": "event_recv from customer 2"},

{"id": 2,"customer-request-id":4,"type": "branch","logical_clock": 13,"interface": "propogate_withdraw","comment": "event_sent to branch 1"},

{"id": 1,"customer-request-id":4,"type": "branch","logical_clock": 14,"interface": "propogate_withdraw","comment": "event_recv from branch 2"},

{"id": 2,"customer-request-id":4,"type": "branch","logical_clock": 15,"interface": "propogate_withdraw","comment": "event_sent to branch 3"},

{"id": 3,"customer-request-id":4,"type": "branch","logical_clock": 16,"interface": "propogate_withdraw","comment": "event_recv from branch 2"},

{"id": 3,"customer-request-id":5,"type": "customer","logical_clock": 1,"interface": "deposit","comment": "event_sent from customer 3"},

{"id": 3,"customer-request-id":5,"type": "branch","logical_clock": 2,"interface": "deposit","comment": "event_recv from customer 3"},

{"id": 3,"customer-request-id":5,"type": "branch","logical_clock": 3,"interface": "propogate_deposit","comment": "event_sent to branch 1"},

{"id": 3,"customer-request-id":5,"type": "branch","logical_clock": 6,"interface": "propogate_deposit","comment": "event_sent to branch 2"},

{"id": 1,"customer-request-id":5,"type": "branch","logical_clock": 8,"interface": "propogate_deposit","comment": "event_recv from branch 3"},

{"id": 2,"customer-request-id":5,"type": "branch","logical_clock": 14,"interface": "propogate_deposit","comment": "event_recv from branch 3"},

{"id": 3,"customer-request-id":6,"type": "customer","logical_clock": 2,"interface": "withdraw","comment": "event_sent from customer 3"},

{"id": 3,"customer-request-id":6,"type": "branch","logical_clock": 13,"interface": "withdraw","comment": "event_recv from customer 3"},

{"id": 3,"customer-request-id":6,"type": "branch","logical_clock": 14,"interface": "propogate_withdraw","comment": "event_sent to branch 1"},

{"id": 1,"customer-request-id":6,"type": "branch","logical_clock": 15,"interface": "propogate_withdraw","comment": "event_recv from branch 3"},

{"id": 3,"customer-request-id":6,"type": "branch","logical_clock": 17,"interface": "propogate_withdraw","comment": "event_sent to branch 2"},

{"id": 2,"customer-request-id":6,"type": "branch","logical_clock": 18,"interface": "propogate_withdraw","comment": "event_recv from branch 3"}]

Submission Directions for Project Deliverables

You must submit your deliverables in the designated submission space in the course. Students may **not** email or use other means to submit the project for course team review and grading. Students should review the academic integrity and plagiarism policies prior to beginning this project.

Your Logical Clock Project includes **two (2)** deliverables.

1. **Logical Clock Project Written Report:** Your written report must be a single PDF with the correct naming convention: Your Name_Logical_Clock_Written Report.
2. **Logical Clock Project Code:** The project code must be submitted as a .zip file of your source code.

Final submissions missing either of the deliverables will be graded based on what was submitted against the rubric criteria. Please review the rubric for how your Logical Clock Project will be graded.

Late submission will not be accepted.