Programming Assignment 2: Internet of Things - Smart Home Edition
OUTPUT/RESULTS DOCUMENT
Submitted by: - Rahul Raj and Olenka Dey

This document shows the generated output from our program for different activities in the smart home designed. The outputs generated is by considering three sensors (Door, Motion and Temperature) and two devices (Smart bulb and Smart outlet) in the network. All these interact with multi-tiered central gateway that logs all the activities. The activities are triggered by the user or the gateway based on the event.

1. First, set up event file that determines the activities in the home as shown in the figure. The USER or GATEWAY tag is to indicate which process is triggering the event (as all events cannot be performed by both).

```
##EVENTlog
##THIS IS THE EVENT LOG. YOU CAN INPUT USER AND GATEWAY EVENT TO THIS LOG AND YOUR SYSTEM WILL FUNCTION ACCORDINGLY.
##IT SHOULD BE SURROUNDED BY START AND STOP AND SHOULD BE WRITTEN IN ALL CAPS.


START
USER:DOOR OPEN PS
USER: MOTION ACTIVE
#USER:DOOR OPEN PS
USER:BULB ON
USER:DOOR OPEN
#USER:DOOR OPEN PS
#USER:MOTION ACTIVE
USER:OUTLET OFF
GATEWAY:QUERY TEMPERATURE
GATEWAY:QUERY MOTION STATE
GATEWAY:QUERY BULB STATE
GATEWAY:QUERY DOOR STATE

### USER: ENTER and EXIT is for "testing" if the gateway properly predicts the sensor activity
#USER:ENTER
#USER:EXIT
STOP
```

2. After saving the config file, run the shell script to start the program.

```
olenka@olenka-VirtualBox:~/DOS/lab2/src$ ./run_me.sh
Starting and registering All the Devices and Sensors with the Gateway.
Waiting...
```

3. First, all the nodes i.e. sensors and devices register themselves with the central gateway through gateway's front-end and it sends the report to the gateway's back-end which logs their initial status.

```
========================================================================================
All device registered !!!

Node Name and Node Type are: {'doorSensor': 'Sensor', 'motionSensor': 'Sensor', 'tempSensor': 'Sensor', 'smartBulb': 'Device', 'smartOutlet': 'Device'}
Node Name and ID are: {'doorSensor': 2, 'motionSensor': 4, 'tempSensor': 3, 'smartBulb': 5, 'smartOutlet': 6}
========================================================================================
```

4. After registering itself with the central gateway, all the processes including gateway and the user participate in Leader Election to select the Time Server/ Master. There are total 8 nodes/processes which participate in this and the output shows how the nodes detect its neighbor in the ring topology and piggyback the active state

information. The output also shows who is initiating the Leader Election (i.e. node 1) and how the leader information is circulated in all the nodes.

```
My neighbor 2  is active
active nodes are [1]
connection established with node:  2

My neighbor 3  is active
active nodes are [1, 2]
connection established with node:  3

My neighbor 4  is active
active nodes are [1, 2, 3]
connection established with node:  4

My neighbor 5  is active
active nodes are [1, 2, 3, 4]
connection established with node:  5

My neighbor 6  is active
active nodes are [1, 2, 3, 4, 5]
connection established with node:  6

My neighbor 7  is active
active nodes are [1, 2, 3, 4, 5, 6]
connection established with node:  7

My neighbor 8  is active
active nodes are [1, 2, 3, 4, 5, 6, 7]
connection established with node:  8

My neighbor 1  is active
election starts .. initiated by 1
Election started from  1
active nodes are [1, 2, 3, 4, 5, 6, 7, 8]
leader elected is  8  reported to 1
connection established with node:  1
leader elected is  8  reported to 2
leader elected is  8  reported to 3
leader elected is  8  reported to 4
leader elected is  8  reported to 5
leader elected is  8  reported to 6
leader elected is  8  reported to 7
leader elected is  8  reported to 8
Election completed
The leader information is circulated to all the nodes. Leader Node:  8
-----------------------------------------
```

5. After leader is being election, the job of the leader is to synchronize every node. The leader node becomes the time server/master and it initiates clock synchronization process before any activity starts. Here the Node 8 is the leader so it starts synchronizing other 7 nodes to match their clocks by collecting their timestamps and sending back offsets to them to adjust their time.

```
The leader information is circulated to all the nodes. Leader Node:  8
-----------------------------------------
Time to Syncronize the clock !!
-----------------------------------------
Initial Timestamps reported by every nodes
[1491129796.551641, 1491129796.776428, 1491129796.891747, 1491129796.975249, 1491129797.046761, 1491129797.08662, 1491129797.131449, 1491129797.146842]
average time  1491129796.95
offset for  1  is 0.399201393127
corrected time  1491129796.95
offset for  2  is 0.174414396286
corrected time  1491129796.95
offset for  3  is 0.0590953826904
corrected time  1491129796.95
offset for  4  is -0.024406671524
corrected time  1491129796.95
offset for  5  is -0.0959186553955
corrected time  1491129796.95
offset for  6  is -0.135777711868
corrected time  1491129796.95
offset for  7  is -0.180606603622
corrected time  1491129796.95
offset for  8  is -0.195999622345
corrected time  1491129796.95
#########################################
```

6. After the leader election and clock synchronization, the application processes start triggering and responding to the events based on the event file. The gateway simultaneously logs the current status to the history file where it keeps track of all the activities and also update the current states stored in the disk. Moreover, as and when the gateway senses any activities on the sensor, it checks if the security of the house is maintained by raising alarm or by correct prediction of the events.

Here in the ouput, user first opens the door with a "presence sensor PS" and then motion sensor reacts, the gateway correctly predicts that the "User Has Entered" on the fly. All the processes maintain the event ordering by implementing the Lamport's Clock.

```
--------------------------------------------------------------------
Started parsing the Event log.
--------------------------------------------------------------------
--------------------------------------------------------------------
This is an User Event: DOOR OPEN PS
Calling doorSensor from User Process. User current clock value is 1
set_state of door is being called from user process.
Closing Door Automatically.
Calling doorSensor from User Process. User current clock value is 2
set_state of door is being called from user process.
Clock value returned from doorSensor is 6 .
State reported by doorSensor is 1
Sending to the backend : node ID is 2 , Sensor/Device name is doorSensor , current state is 1
--------------------------------------------------------------------
This is an User Event: MOTION ACTIVE
Calling motionSensor from User Process. User current clock value is 3
Clock value returned from doorSensor is 8 .
State reported by doorSensor is 0
Sending to the backend : node ID is 2 , Sensor/Device name is doorSensor , current state is 0
set_state of motionSensor is being called from user process.
Turning on Lights.
Calling smartBulb from User Process. User current clock value is 4
{'doorSensor': 2, 'motionSensor': 4}
USER ENTERING!! TURN OFF SECURITY SYSTEM
Clock value returned from motionSensor is 6 .
State reported by motionSensor is 1
Sending to the backend : node ID is 5 , Sensor/Device name is motionSensor , current state is 1
set_state of bulb is being called.
--------------------------------------------------------------------
```

Another example of gateway maintaining the security system is as below. It shows when any intruder tries to enter, i.e. without the presence sensor PS, gateway "raises an Alarm".

```
-----------------------------    ------------------------
This is an User Event: DOOR OPEN
INTRUDER!! SOUND ALARM!!
------------------------------------
```

Similarly, gateway events are also recorded and the event ordering is maintained using lamport's clock algorithm.

```
This is an Gateway event: QUERY TEMPERATURE
Calling tempSensor from Gateway Front End. Gateway current clock value is 14
Clock value returned from tempSensor is 15 .
State reported by tempSensor is 54
Sending to the backend : node ID is 6 , Sensor/Device name is tempSensor , current state is 54
--------------------------------------------------------------------
This is an Gateway event: QUERY MOTION STATE
Calling motionSensor from Gateway Front End. Gateway current clock value is 17
Motion sensor state returned is 1
--------------------------------------------------------------------
This is an Gateway event: QUERY BULB STATE
Calling smartBulb from Gateway Front End. Gateway current clock value is 18
Bulb device state returned is 1
--------------------------------------------------------------------
This is an Gateway event: QUERY DOOR STATE
Calling doorSensor from Gateway Front End. Gateway current clock value is 19
Door sensor state returned is 0
--------------------------------------------------------------------
Reached end of log file. Finished Parsing.
--------------------------------------------------------------------
```

7. After all the events have been executed from the event file, the system generates the plot to show events that have occurred and verify if the ordering is maintained or not.
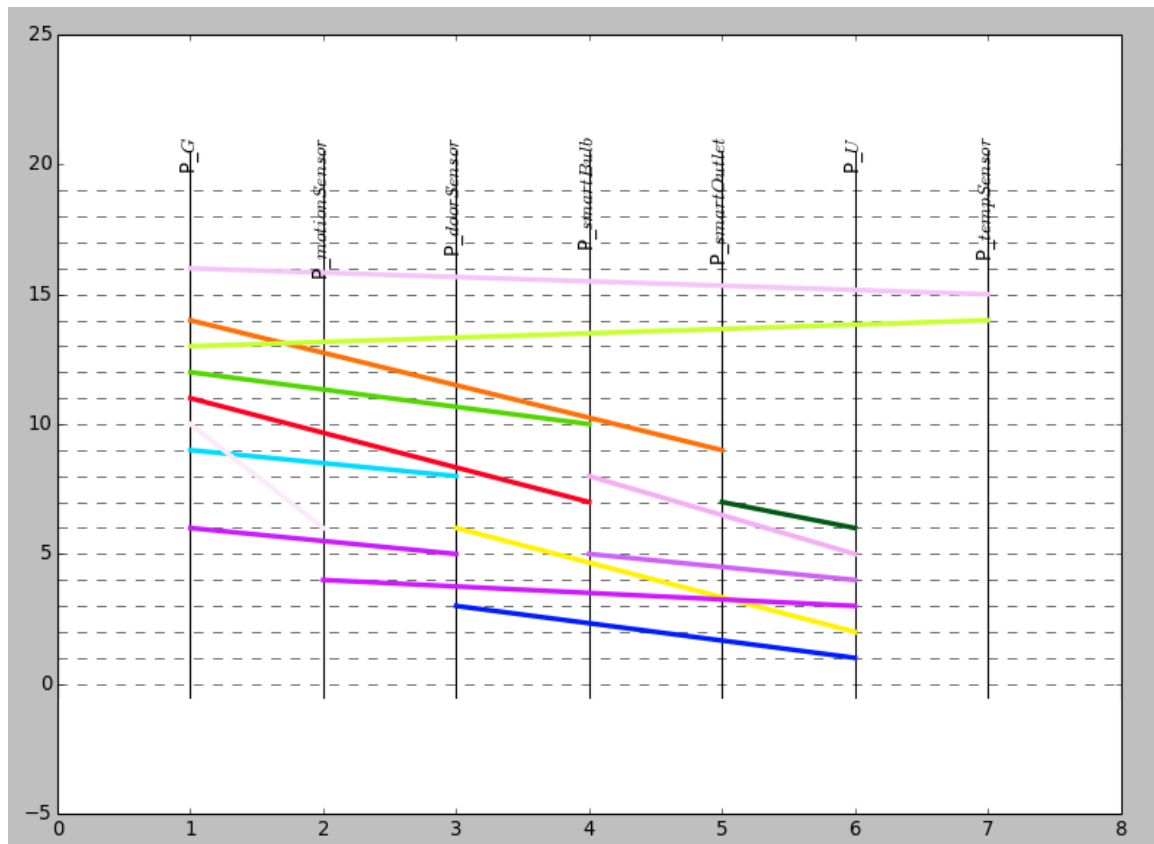
8. As an output, the system also generates three files:

a. current_status.txt: it tells you about the latest state of each of the sensors/device. The highlighted column shows the most recent state.

```
1491134010.39 2 smartBulb 1
1491134013.28 4 tempSensor 40
1491134006.45 3 doorSensor 0
1491134011.73 6 smartOutlet 0
1491134008.03 5 motionSensor 1
```

b. history.csv: It keeps track of all the state changes in that happened in the sensors and devices during the activities.

	A	B	C	D
1	1491134499.41258	2	smartOutlet	0
2	1491134499.43127	3	tempSensor	0
3	1491134499.63915	4	smartBulb	0
4	1491134499.9631	5	motionSensor	0
5	1491134500.60679	6	doorSensor	0
6	1491134508.48102	6	doorSensor	1
7	1491134509.51962	6	doorSensor	0
8	1491134510.8221	5	motionSensor	1
9	1491134511.95407	4	smartBulb	1
10	1491134513.67407	4	smartBulb	1
11	1491134514.9818	2	smartOutlet	0
12	1491134516.72241	3	tempSensor	40

1st column is the timestamp, 2nd column is the node ID, 3rd column is the node name and the 4th column indicates the states of the nodes.

c. LamportEventLog.txt: This file is to register all the events and their respective clock value. This file is to verify the event ordering. Here first two columns indicates the source information and next two column indicates the destination information for a particular event. One can verify the sequence of events with the actual events using this output file.

```
[1, 'U', 'doorSensor', 3]
[5, 'doorSensor', 'G', 6]
[2, 'U', 'doorSensor', 6]
[8, 'doorSensor', 'G', 9]
[3, 'U', 'motionSensor', 4]
[6, 'motionSensor', 'G', 10]
[4, 'U', 'smartBulb', 5]
[7, 'smartBulb', 'G', 11]
[5, 'U', 'smartBulb', 8]
[10, 'smartBulb', 'G', 12]
[6, 'U', 'smartOutlet', 7]
[9, 'smartOutlet', 'G', 14]
[13, 'G', 'tempSensor', 14]
[15, 'tempSensor', 'G', 16]
[17, 'G', 'motionSensor', 18]
[18, 'G', 'smartBulb', 19]
[19, 'G', 'doorSensor', 20]
```

Complete output view:

```
olenka@olenka-VirtualBox:~/DOS/lab2/src$ ./run_me.sh
Starting and registering All the Devices and Sensors with the Gateway.
Waiting...
8001/tcp:           6140
Running Leader Election algorithm at all the nodes.
olenka@olenka-VirtualBox:~/DOS/lab2/src$ Clock value returned from smartOutlet is 0 .
State reported by smartOutlet is 0
Sending to the backend : node ID is 2 , Sensor/Device name is smartOutlet , current state is 0
Clock value returned from doorSensor is 0 .
State reported by doorSensor is 0
Sending to the backend : node ID is 3 , Sensor/Device name is doorSensor , current state is 0
Clock value returned from smartBulb is 0 .
State reported by smartBulb is 0
Sending to the backend : node ID is 4 , Sensor/Device name is smartBulb , current state is 0
Clock value returned from tempSensor is 0 .
State reported by tempSensor is 0
Sending to the backend : node ID is 5 , Sensor/Device name is tempSensor , current state is 0
Clock value returned from motionSensor is 0 .
State reported by motionSensor is 0
Sending to the backend : node ID is 6 , Sensor/Device name is motionSensor , current state is 0


=========================================================================================================
All device registered !!!

Node Name and Node Type are: {'doorSensor': 'Sensor', 'motionSensor': 'Sensor', 'tempSensor': 'Sensor', 'smartBulb': 'Device', 'smartOutlet': 'Device'}
Node Name and ID are: {'doorSensor': 3, 'motionSensor': 6, 'tempSensor': 5, 'smartBulb': 4, 'smartOutlet': 2}
=========================================================================================================

My neighbor 2  is active
active nodes are [1]
connection established with node:  2

My neighbor 3  is active
active nodes are [1, 2]
connection established with node:  3

My neighbor 4  is active
active nodes are [1, 2, 3]
connection established with node:  4

My neighbor 5  is active
active nodes are [1, 2, 3, 4]
connection established with node:  5

My neighbor 6  is active
active nodes are [1, 2, 3, 4, 5]
connection established with node:  6

My neighbor 7  is active
```

```
My neighbor 7  is active
active nodes are [1, 2, 3, 4, 5, 6]
connection established with node:  7

My neighbor 8  is active
active nodes are [1, 2, 3, 4, 5, 6, 7]
connection established with node:  8

My neighbor 1  is active
election starts .. initiated by 1
Election started from  1
active nodes are [1, 2, 3, 4, 5, 6, 7, 8]
connection established with node:  1
leader elected is  8  reported to 1
leader elected is  8  reported to 2
leader elected is  8  reported to 3
leader elected is  8  reported to 4
leader elected is  8  reported to 5
leader elected is  8  reported to 6
leader elected is  8  reported to 7
leader elected is  8  reported to 8
Election completed
The leader information is circulated to all the nodes. Leader Node:  8
----------------------------------------
Time to Syncronize the clock !!
----------------------------------------
Initial Timestamps reported by every nodes
[1491135159.762696, 1491135159.811778, 1491135159.860013, 1491135159.962611, 1491135160.047442, 1491135160.110344, 1491135160.191442, 1491135160.210547]
average time  1491135159.99
offset for  1  is 0.231913089752
corrected time  1491135159.99
offset for  2  is 0.182831048965
corrected time  1491135159.99
offset for  3  is 0.13459610939
corrected time  1491135159.99
offset for  4  is 0.0319981575012
corrected time  1491135159.99
offset for  5  is -0.0528328418732
corrected time  1491135159.99
offset for  6  is -0.115734815598
corrected time  1491135159.99
offset for  7  is -0.196832895279
corrected time  1491135159.99
offset for  8  is -0.215937852859
corrected time  1491135159.99
#########################################
-----------------------------------------------------------------
Started parsing the Event log.
-----------------------------------------------------------------------------
Started parsing the Event log.
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
This is an User Event: DOOR OPEN PS
Calling doorSensor from User Process. User current clock value is 1
set_state of door is being called from user process.
Closing Door Automatically.
Calling doorSensor from User Process. User current clock value is 2
set_state of door is being called from user process.
Clock value returned from doorSensor is 6 .
State reported by doorSensor is 1
Sending to the backend : node ID is 3 , Sensor/Device name is doorSensor , current state is 1
-----------------------------------------------------------------------------
This is an User Event: MOTION ACTIVE
Calling motionSensor from User Process. User current clock value is 3
Clock value returned from doorSensor is 8 .
State reported by doorSensor is 0
Sending to the backend : node ID is 3 , Sensor/Device name is doorSensor , current state is 0
set_state of motionSensor is being called from user process.
Turning on Lights.
Calling smartBulb from User Process. User current clock value is 4
{'doorSensor': 2, 'motionSensor': 4}
USER ENTERING!! TURN OFF SECURITY SYSTEM
Clock value returned from motionSensor is 6 .
State reported by motionSensor is 1
Sending to the backend : node ID is 6 , Sensor/Device name is motionSensor , current state is 1
set_state of bulb is being called.
Clock value returned from smartBulb is 7 .
State reported by smartBulb is 1
Sending to the backend : node ID is 4 , Sensor/Device name is smartBulb , current state is 1
-----------------------------------------------------------------------------
This is an User Event: BULB ON
Calling smartBulb from User Process. User current clock value is 5
set_state of bulb is being called.
Clock value returned from smartBulb is 10 .
State reported by smartBulb is 1
Sending to the backend : node ID is 4 , Sensor/Device name is smartBulb , current state is 1
-----------------------------------------------------------------------------
This is an User Event: DOOR OPEN
INTRUDER!! SOUND ALARM!!
-----------------------------------------------------------------------------
This is an User Event: OUTLET OFF
Calling smartOutlet from User Process. User current clock value is 6
set_state of outlet is being called.
-----------------------------------------------------------------------------
This is an Gateway event: QUERY TEMPERATURE
Clock value returned from smartOutlet is 9 .
State reported by smartOutlet is 0
Sending to the backend : node ID is 2 , Sensor/Device name is smartOutlet , current state is 0
Calling tempSensor from Gateway Front End. Gateway current clock value is 14
```

```
-------------------------------------------------------------------------
This is an Gateway event: QUERY TEMPERATURE
Clock value returned from smartOutlet is 9 .
State reported by smartOutlet is 0
Sending to the backend : node ID is 2 , Sensor/Device name is smartOutlet , current state is 0
Calling tempSensor from Gateway Front End. Gateway current clock value is 14
Clock value returned from tempSensor is 16 .
State reported by tempSensor is 55
Sending to the backend : node ID is 5 , Sensor/Device name is tempSensor , current state is 55
-------------------------------------------------------------------------
This is an Gateway event: QUERY MOTION STATE
Calling motionSensor from Gateway Front End. Gateway current clock value is 18
Motion sensor state returned is 1
-------------------------------------------------------------------------
This is an Gateway event: QUERY BULB STATE
Calling smartBulb from Gateway Front End. Gateway current clock value is 19
Bulb device state returned is 1
-------------------------------------------------------------------------
This is an Gateway event: QUERY DOOR STATE
Calling doorSensor from Gateway Front End. Gateway current clock value is 20
Door sensor state returned is 0
-------------------------------------------------------------------------
Reached end of log file. Finished Parsing.
-------------------------------------------------------------------------
```