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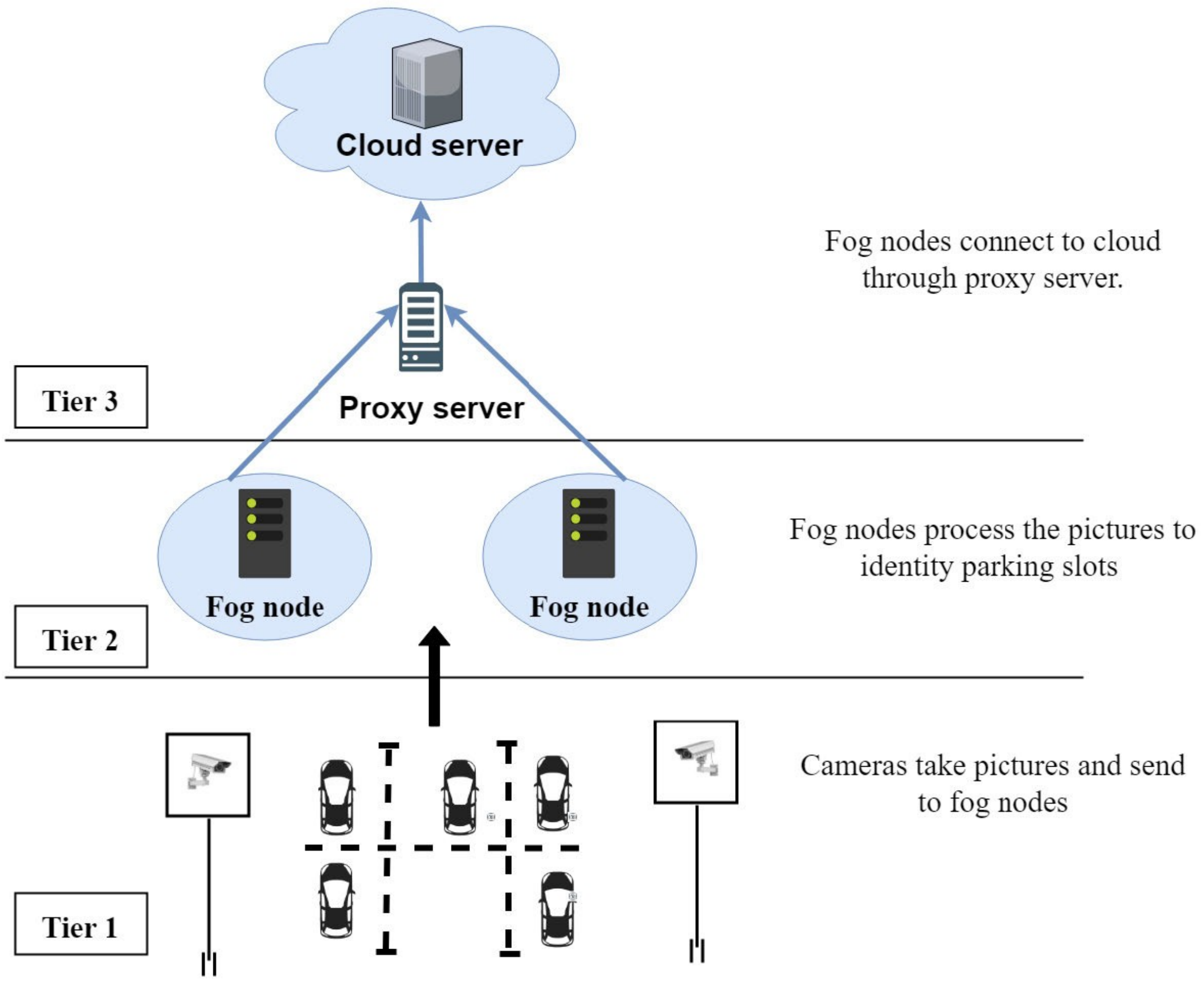
SMART VEHICLE PARKING SYSTEM

System Architecture.



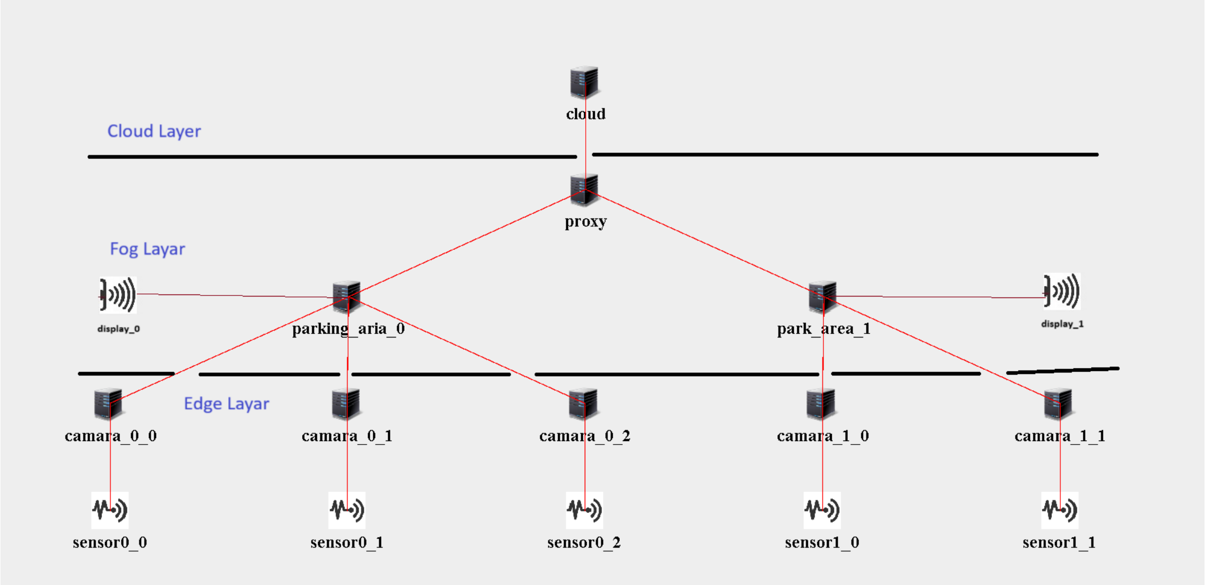
Fog nodes connect to cloud through proxy server.

Fog nodes process the pictures to identity parking slots

Cameras take pictures and send to fog nodes

Multiple camara and LCD is fixed at each area, there are N areas, connected to cloud via proxy. Camaras will capture the photo of parking slots, whether the slot is empty or not is found by system and status of each parking slot will be update as well as displayed at LCD display fixed at entrence in each parking area, notification also send to registered customers about status at each parking aria. again, the status of each slot and parking aria with time will be stored on cloud data center for future use.

Topology of the system:



Parameters	Cloud	Proxy	Fog	Edge
CPU Speed (MIPS)	44800	2800	5600	1000
RAM(MB)	40000	4000	8000	1000
U/p Link bandwidth	100	10000	10000	10000
D/n Link bandwidth	10000	10000	10000	10000
Level	0	1	2	3
Rate (Cost) per MIPS	0.01	0.0	0.0	0.0
Busy Power (Watt)	16*103	107.339	107.339	107.339
Idle power (Watt)	16*83.25	83.43	83.43	83.43

system application model DIAGRAM:

CAMARA_SENSER Captures raw image (RAW_DATA) and set for processing to CLIENT_DATA_CLEANER module,

CLIENT_DATA_CLEANER module process raw data convert to CLEANED_DATA ,

Object_Identifier module identifies the object in the CLEANED_DATA and upload to **Storekeeper** module for storing data,

Object_Identifier also sends tuple NOTIFY_CLIENTS to **Broadcaster** module and intern Broadcaster module notify all the register vehicle owners about status of each parking aria.

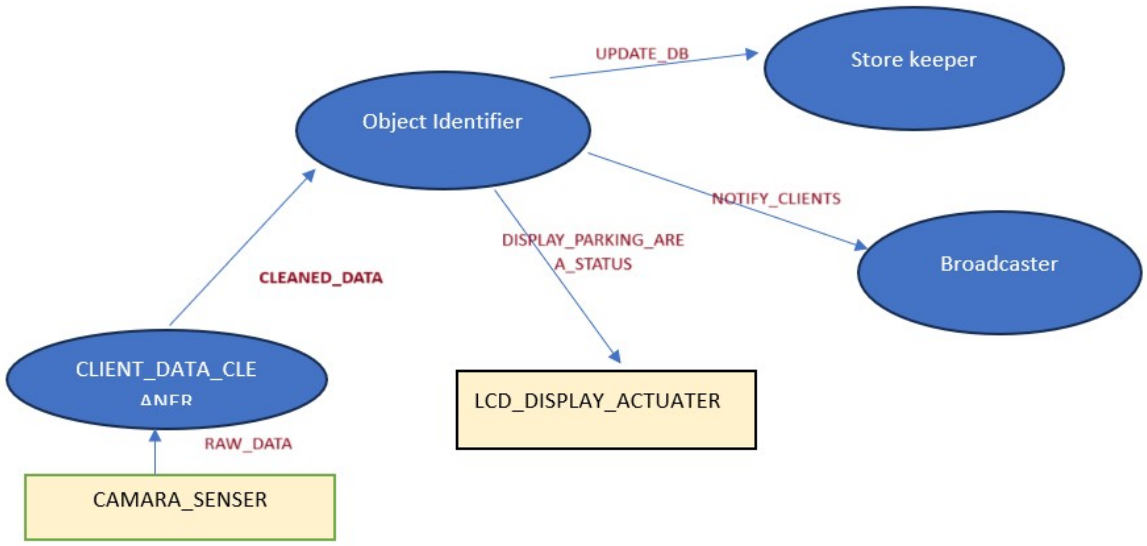
Object Identifier also sends tuple DISPLAY_PARKING_AREA_STATUS TO DISPLAY on **LCD_DISPLAY** located at gate of each parking area.

MODULE	**RAM**
CLIENT_DATA_CLEANER	10
ObjectIdentifier	10
Storekeeper	10
Broadcaster	10

Senser: **CAMARA_SENSER**

Actuator: **LCD_DISPLAY_ACTUATER**

RAW_DATA



Tuple Type	**CPU length**	**Network length**	**Priority**
RAW_DATA	1000	4000	1
CLEANED_DATA	4000	2000	1
UPDATE_DB	1000	500	2
NOTOIFY_CLIENT	1000	500	2
DISPLAY_PARKING_AREA_STATUS	0	4000	1

LOOP (JOB) delay:

[CAMARA_SENSER, CLIENT_DATA_CLEANER, ObjectIdentifier, **LCD_DISPLAY_ACTUATER]**

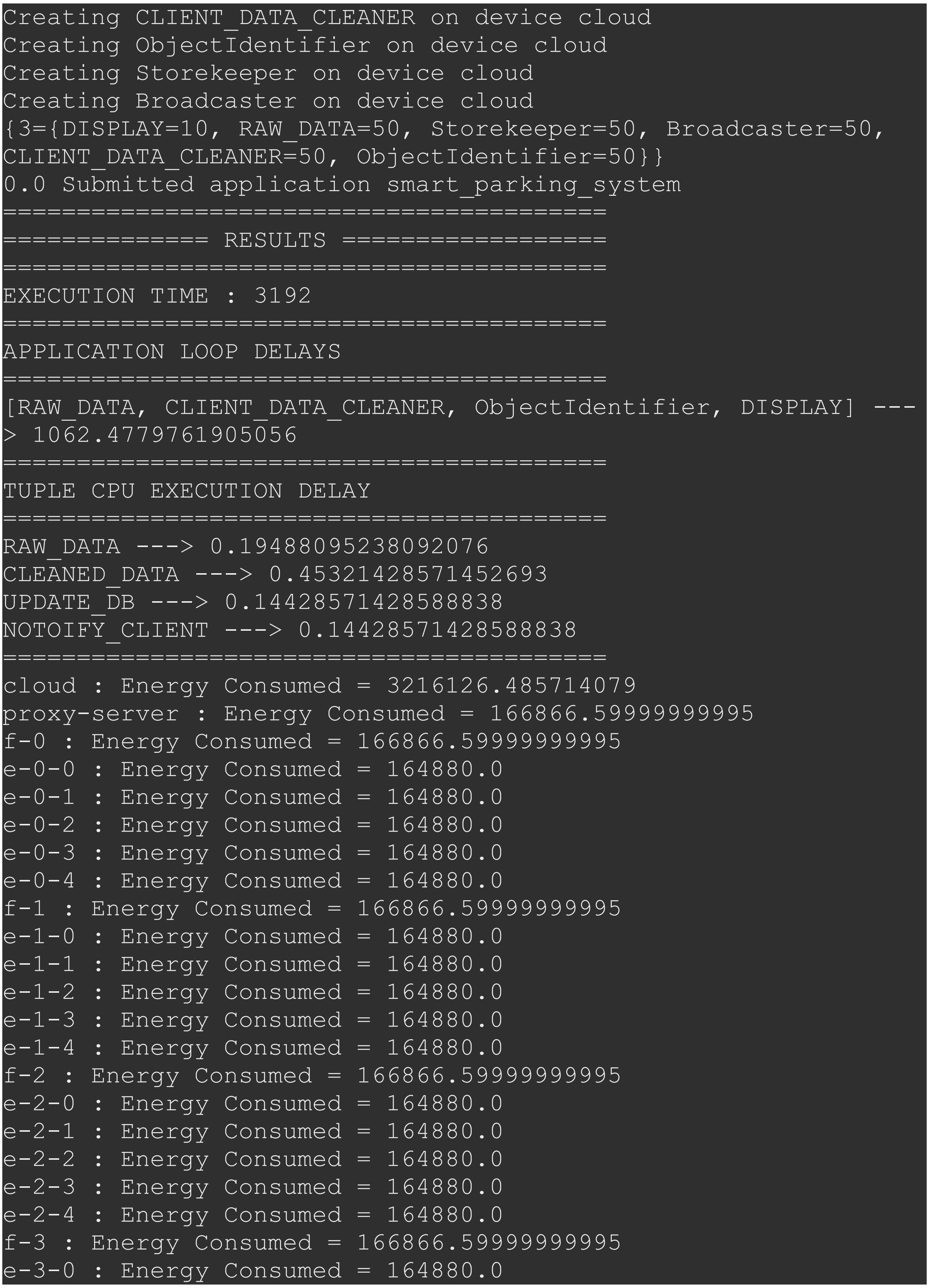
[CAMARA_SENSER, CLIENT_DATA_CLEANER, ObjectIdentifier, StoreKeeper]

[CAMARA_SENSER, CLIENT_DATA_CLEANER, ObjectIdentifier, Broadcaster]

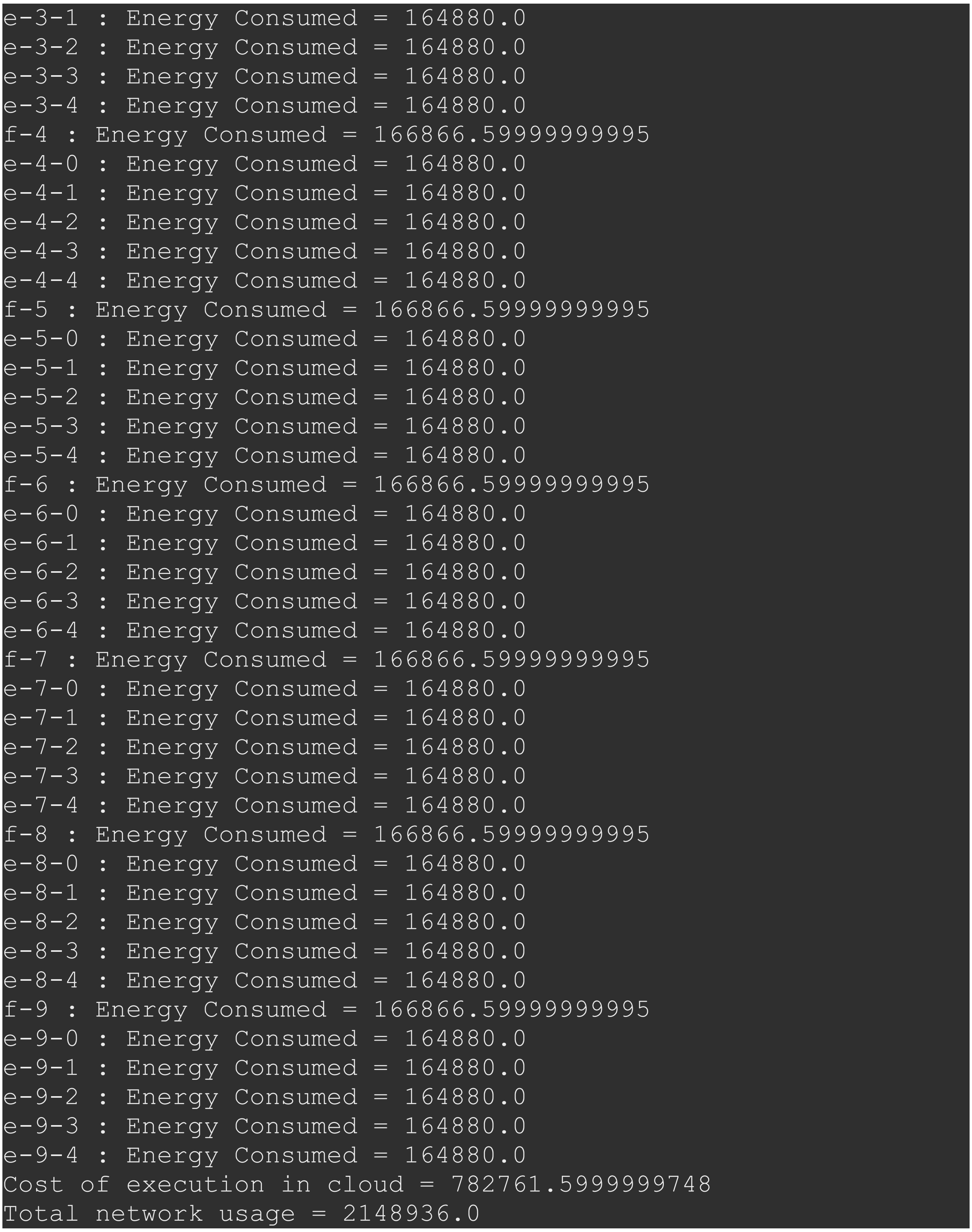
Simulation details:

Case 1:

When we have a single Q and all the tasks have the same priority and carried out by cloud centre. The results shown as bellow.



```
Creating CLIENT_DATA_CLEANER on device cloud
Creating ObjectIdentifier on device cloud
Creating Storekeeper on device cloud
Creating Broadcaster on device cloud
{3={DISPLAY=10, RAW_DATA=50, Storekeeper=50, Broadcaster=50,
CLIENT_DATA_CLEANER=50, ObjectIdentifier=50}}
0.0 Submitted application smart_parking_system
=========================================
============== RESULTS ==================
=========================================
EXECUTION TIME : 3192
=========================================
APPLICATION LOOP DELAYS
=========================================
[RAW_DATA, CLIENT_DATA_CLEANER, ObjectIdentifier, DISPLAY] ---
> 1062.4779761905056
=========================================
TUPLE CPU EXECUTION DELAY
=========================================
RAW_DATA ---> 0.19488095238092076
CLEANED_DATA ---> 0.45321428571452693
UPDATE_DB ---> 0.14428571428588838
NOTOIFY_CLIENT ---> 0.14428571428588838
=========================================
cloud : Energy Consumed = 3216126.485714079
proxy-server : Energy Consumed = 166866.59999999995
f-0 : Energy Consumed = 166866.59999999995
e-0-0 : Energy Consumed = 164880.0
e-0-1 : Energy Consumed = 164880.0
e-0-2 : Energy Consumed = 164880.0
e-0-3 : Energy Consumed = 164880.0
e-0-4 : Energy Consumed = 164880.0
f-1 : Energy Consumed = 166866.59999999995
e-1-0 : Energy Consumed = 164880.0
e-1-1 : Energy Consumed = 164880.0
e-1-2 : Energy Consumed = 164880.0
e-1-3 : Energy Consumed = 164880.0
e-1-4 : Energy Consumed = 164880.0
f-2 : Energy Consumed = 166866.59999999995
e-2-0 : Energy Consumed = 164880.0
e-2-1 : Energy Consumed = 164880.0
e-2-2 : Energy Consumed = 164880.0
e-2-3 : Energy Consumed = 164880.0
e-2-4 : Energy Consumed = 164880.0
f-3 : Energy Consumed = 166866.59999999995
e-3-0 : Energy Consumed = 164880.0
```

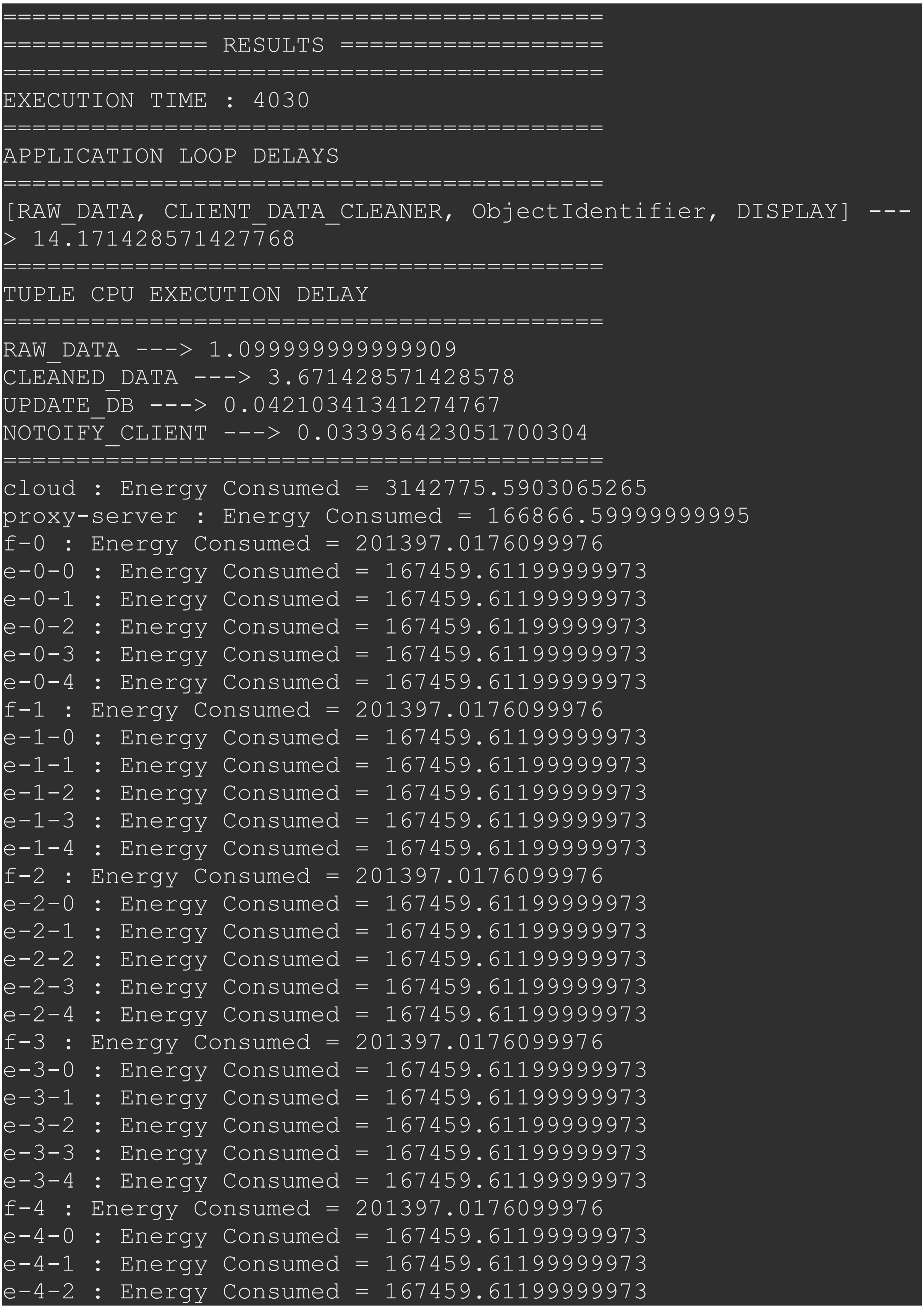


```
e-3-1 : Energy Consumed = 164880.0
e-3-2 : Energy Consumed = 164880.0
e-3-3 : Energy Consumed = 164880.0
e-3-4 : Energy Consumed = 164880.0
f-4 : Energy Consumed = 166866.59999999995
e-4-0 : Energy Consumed = 164880.0
e-4-1 : Energy Consumed = 164880.0
e-4-2 : Energy Consumed = 164880.0
e-4-3 : Energy Consumed = 164880.0
e-4-4 : Energy Consumed = 164880.0
f-5 : Energy Consumed = 166866.59999999995
e-5-0 : Energy Consumed = 164880.0
e-5-1 : Energy Consumed = 164880.0
e-5-2 : Energy Consumed = 164880.0
e-5-3 : Energy Consumed = 164880.0
e-5-4 : Energy Consumed = 164880.0
f-6 : Energy Consumed = 166866.59999999995
e-6-0 : Energy Consumed = 164880.0
e-6-1 : Energy Consumed = 164880.0
e-6-2 : Energy Consumed = 164880.0
e-6-3 : Energy Consumed = 164880.0
e-6-4 : Energy Consumed = 164880.0
f-7 : Energy Consumed = 166866.59999999995
e-7-0 : Energy Consumed = 164880.0
e-7-1 : Energy Consumed = 164880.0
e-7-2 : Energy Consumed = 164880.0
e-7-3 : Energy Consumed = 164880.0
e-7-4 : Energy Consumed = 164880.0
f-8 : Energy Consumed = 166866.59999999995
e-8-0 : Energy Consumed = 164880.0
e-8-1 : Energy Consumed = 164880.0
e-8-2 : Energy Consumed = 164880.0
e-8-3 : Energy Consumed = 164880.0
e-8-4 : Energy Consumed = 164880.0
f-9 : Energy Consumed = 166866.59999999995
e-9-0 : Energy Consumed = 164880.0
e-9-1 : Energy Consumed = 164880.0
e-9-2 : Energy Consumed = 164880.0
e-9-3 : Energy Consumed = 164880.0
e-9-4 : Energy Consumed = 164880.0
Cost of execution in cloud = 782761.5999999748
Total network usage = 2148936.0
```

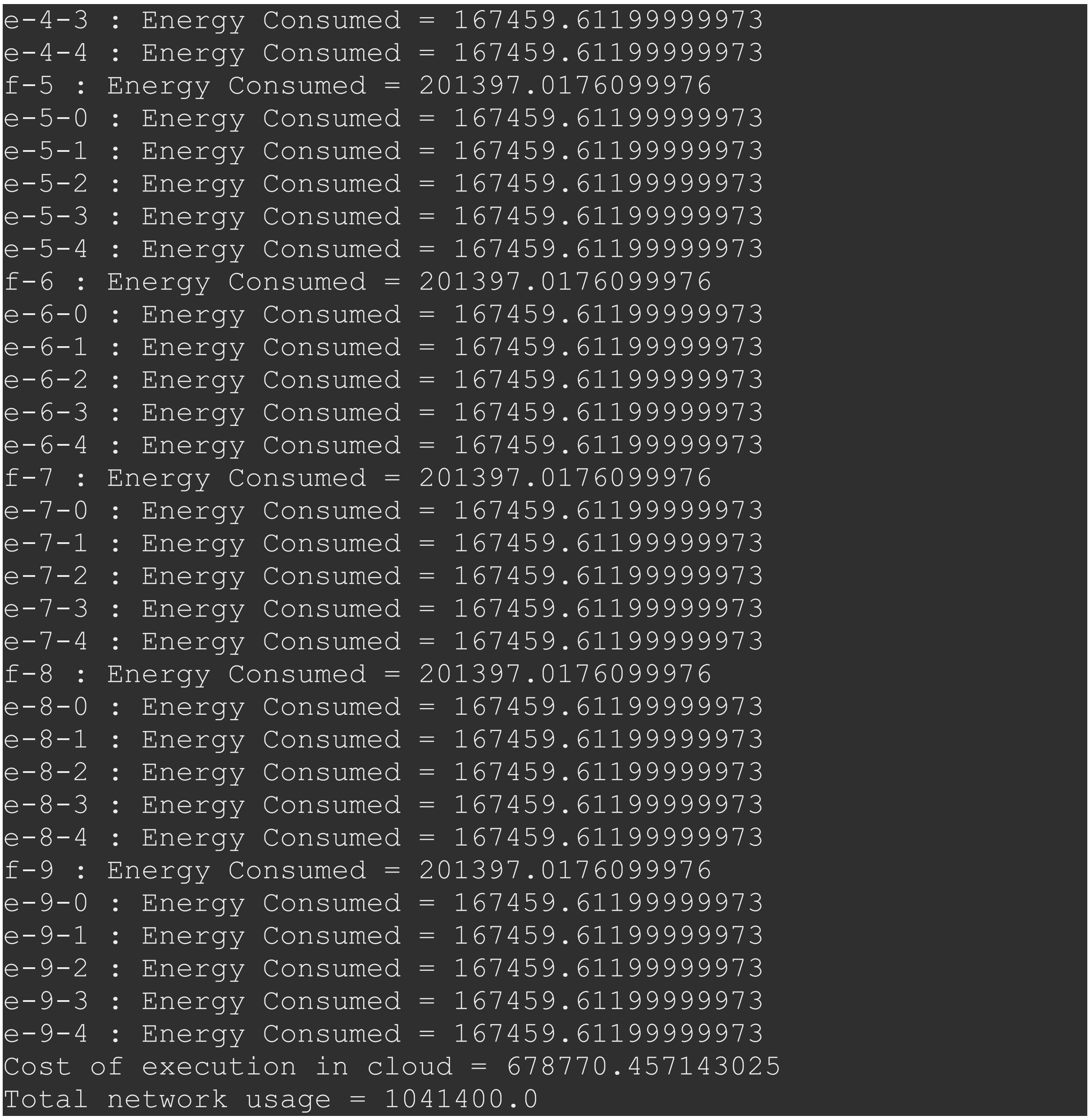
Case 2(A Multi-Queue Priority-Based Task Scheduling Algorithm):

Here multiple Qs are maintained such that each tuple (task) type will have its Q with its priority based on its burst time(starvation problem for less latency-sensitive long tasks). assignment of various tasks to the fog node while taking into account both the resource availability and the required QoS criteria.

particular Q will be assigned to particular device /fog resources based on priority of Q(task size in Q) and capability of resource(speed of the device) to achieve Quality of service in terms of improved response time.



```
=========================================
============== RESULTS ==================
=========================================
EXECUTION TIME : 4030
=========================================
APPLICATION LOOP DELAYS
=========================================
[RAW_DATA, CLIENT_DATA_CLEANER, ObjectIdentifier, DISPLAY] ---
> 14.171428571427768
=========================================
TUPLE CPU EXECUTION DELAY
=========================================
RAW_DATA ---> 1.0999999999999909
CLEANED_DATA ---> 3.671428571428578
UPDATE_DB ---> 0.04210341341274767
NOTOIFY_CLIENT ---> 0.033936423051700304
=========================================
cloud : Energy Consumed = 3142775.5903065265
proxy-server : Energy Consumed = 166866.59999999995
f-0 : Energy Consumed = 201397.0176099976
e-0-0 : Energy Consumed = 167459.61199999973
e-0-1 : Energy Consumed = 167459.61199999973
e-0-2 : Energy Consumed = 167459.61199999973
e-0-3 : Energy Consumed = 167459.61199999973
e-0-4 : Energy Consumed = 167459.61199999973
f-1 : Energy Consumed = 201397.0176099976
e-1-0 : Energy Consumed = 167459.61199999973
e-1-1 : Energy Consumed = 167459.61199999973
e-1-2 : Energy Consumed = 167459.61199999973
e-1-3 : Energy Consumed = 167459.61199999973
e-1-4 : Energy Consumed = 167459.61199999973
f-2 : Energy Consumed = 201397.0176099976
e-2-0 : Energy Consumed = 167459.61199999973
e-2-1 : Energy Consumed = 167459.61199999973
e-2-2 : Energy Consumed = 167459.61199999973
e-2-3 : Energy Consumed = 167459.61199999973
e-2-4 : Energy Consumed = 167459.61199999973
f-3 : Energy Consumed = 201397.0176099976
e-3-0 : Energy Consumed = 167459.61199999973
e-3-1 : Energy Consumed = 167459.61199999973
e-3-2 : Energy Consumed = 167459.61199999973
e-3-3 : Energy Consumed = 167459.61199999973
e-3-4 : Energy Consumed = 167459.61199999973
f-4 : Energy Consumed = 201397.0176099976
e-4-0 : Energy Consumed = 167459.61199999973
e-4-1 : Energy Consumed = 167459.61199999973
e-4-2 : Energy Consumed = 167459.61199999973
```

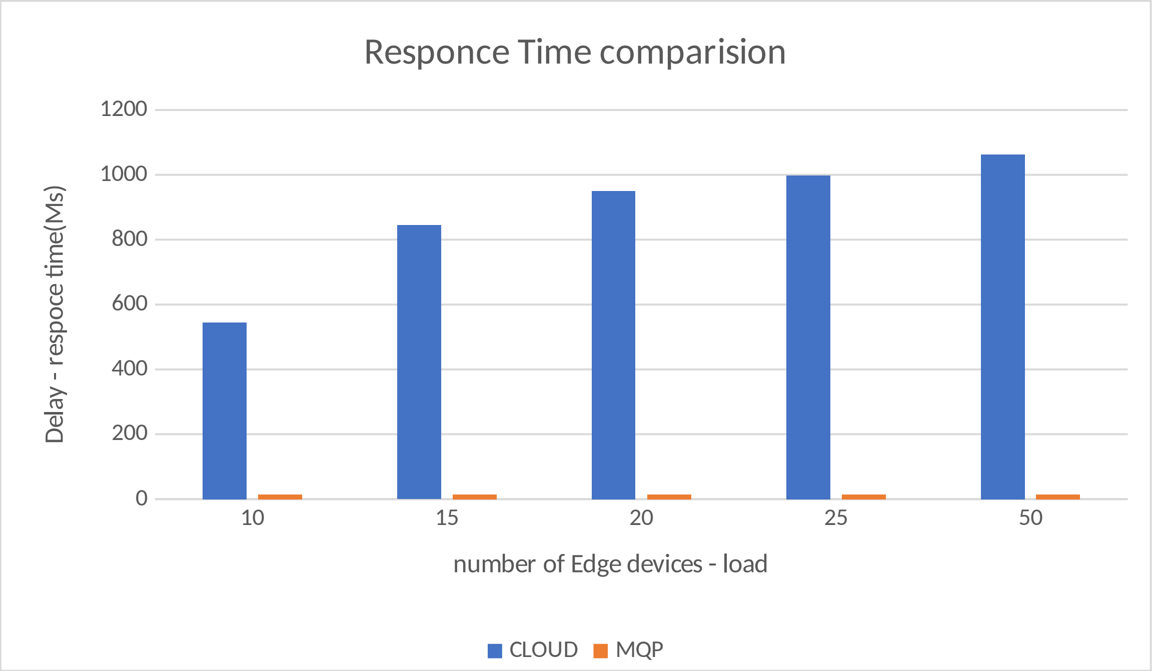


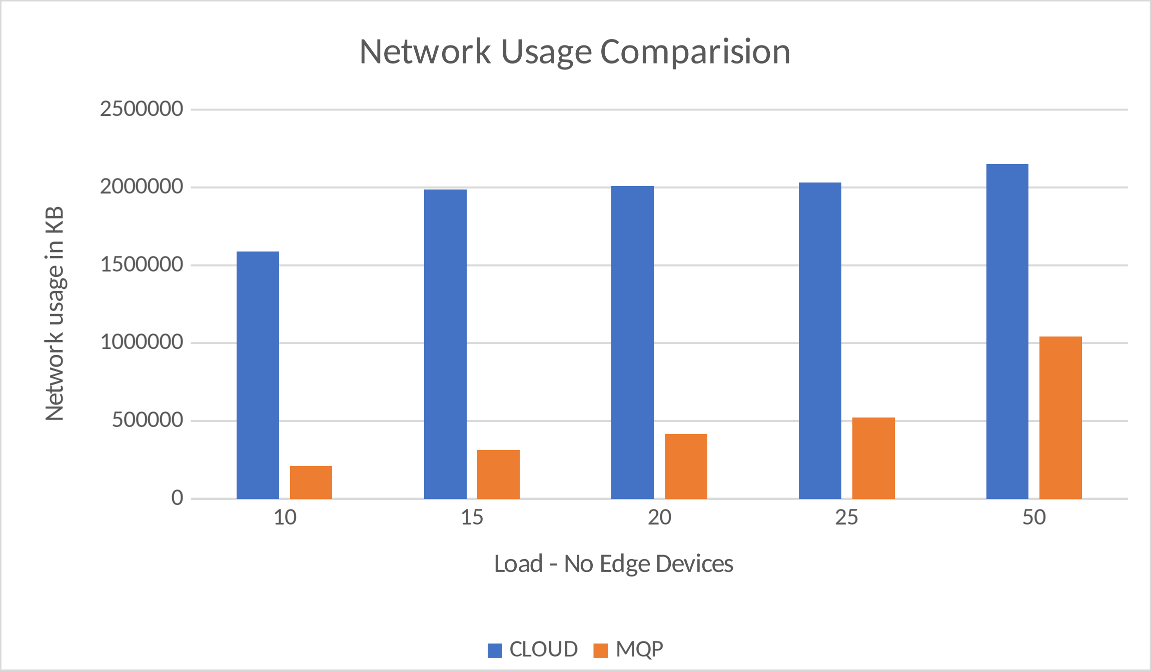
```
e-4-3 : Energy Consumed = 167459.61199999973
e-4-4 : Energy Consumed = 167459.61199999973
f-5 : Energy Consumed = 201397.0176099976
e-5-0 : Energy Consumed = 167459.61199999973
e-5-1 : Energy Consumed = 167459.61199999973
e-5-2 : Energy Consumed = 167459.61199999973
e-5-3 : Energy Consumed = 167459.61199999973
e-5-4 : Energy Consumed = 167459.61199999973
f-6 : Energy Consumed = 201397.0176099976
e-6-0 : Energy Consumed = 167459.61199999973
e-6-1 : Energy Consumed = 167459.61199999973
e-6-2 : Energy Consumed = 167459.61199999973
e-6-3 : Energy Consumed = 167459.61199999973
e-6-4 : Energy Consumed = 167459.61199999973
f-7 : Energy Consumed = 201397.0176099976
e-7-0 : Energy Consumed = 167459.61199999973
e-7-1 : Energy Consumed = 167459.61199999973
e-7-2 : Energy Consumed = 167459.61199999973
e-7-3 : Energy Consumed = 167459.61199999973
e-7-4 : Energy Consumed = 167459.61199999973
f-8 : Energy Consumed = 201397.0176099976
e-8-0 : Energy Consumed = 167459.61199999973
e-8-1 : Energy Consumed = 167459.61199999973
e-8-2 : Energy Consumed = 167459.61199999973
e-8-3 : Energy Consumed = 167459.61199999973
e-8-4 : Energy Consumed = 167459.61199999973
f-9 : Energy Consumed = 201397.0176099976
e-9-0 : Energy Consumed = 167459.61199999973
e-9-1 : Energy Consumed = 167459.61199999973
e-9-2 : Energy Consumed = 167459.61199999973
e-9-3 : Energy Consumed = 167459.61199999973
e-9-4 : Energy Consumed = 167459.61199999973
Cost of execution in cloud = 678770.457143025
Total network usage = 1041400.0
```

Comparison for Delay and network usage for both cases will be presented in the table as well as in graphs.

Results Comparison Table:

Load: number of camaras (parking slots)	Default		MQP assigned to Resource	
	delay	Network usage	delay	Network usage
2*5	545.2922089211496	1587160	14.171428571427816	208500
3*5	844.6749627459058	1986032.0	14.17142857142724	312750
4*5	949.6674417450304	2009304.0	14.171428571426949	417000.0
5*5	997.8265663797641	2032576	14.17142857142681	521250
10*5	1062.4779761905056	2148936	14.171428571427768	1041400





algorithm is as follows

```
Input: Qs (type list)    //list of Tasktype-Q in the system
       : no_IoTLayers  //number of layers on IoT
Algorithm:
       layer = no_IoTLayers // we start Q assignment to resource from edge
      the  for the Q in Qs
           if layer_Device_Capacity(layer) allows Q
              place Q in layer
           else
              layer = layer - 1 //  Q assignment to resource  should shift to the upper layer
       next for_loop
```