Cloud-Based Smart Energy Framework for Accelerated Data Analytics with Parallel Computing of Orchestrated Containers: Study Case of CU-BEMS

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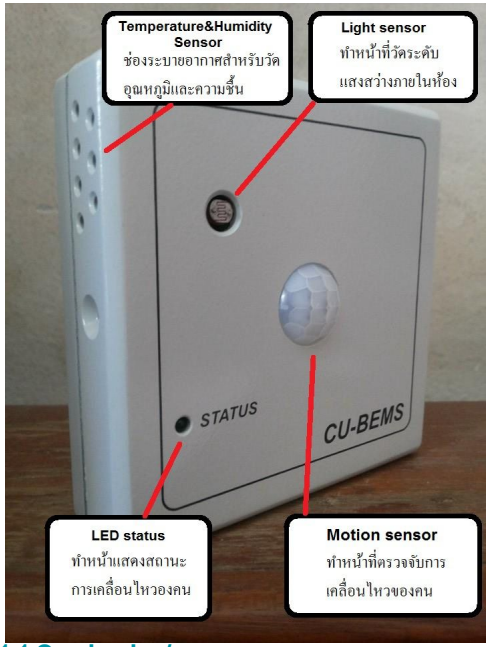
IoT cloudserve @TEIN

CUBEMS

CUBEMS is a smart energy system of buildings in Chulalongkorn University. There are a lot of sensor boxes in the buildings. Each sensor box contains of temperature, humidity, illuminance, and PIR (motion detector) sensors. All sensors' data are collected in CUBEMS storage.



- Try: http://newwebserver.parallelcomputingdemo.161.200.90.110.xip.io/now

CUBEMS
CHAMCHURI 5

CUBEMS
CHAMCHURI 5

Security Awareness (1) : Why we need it ?

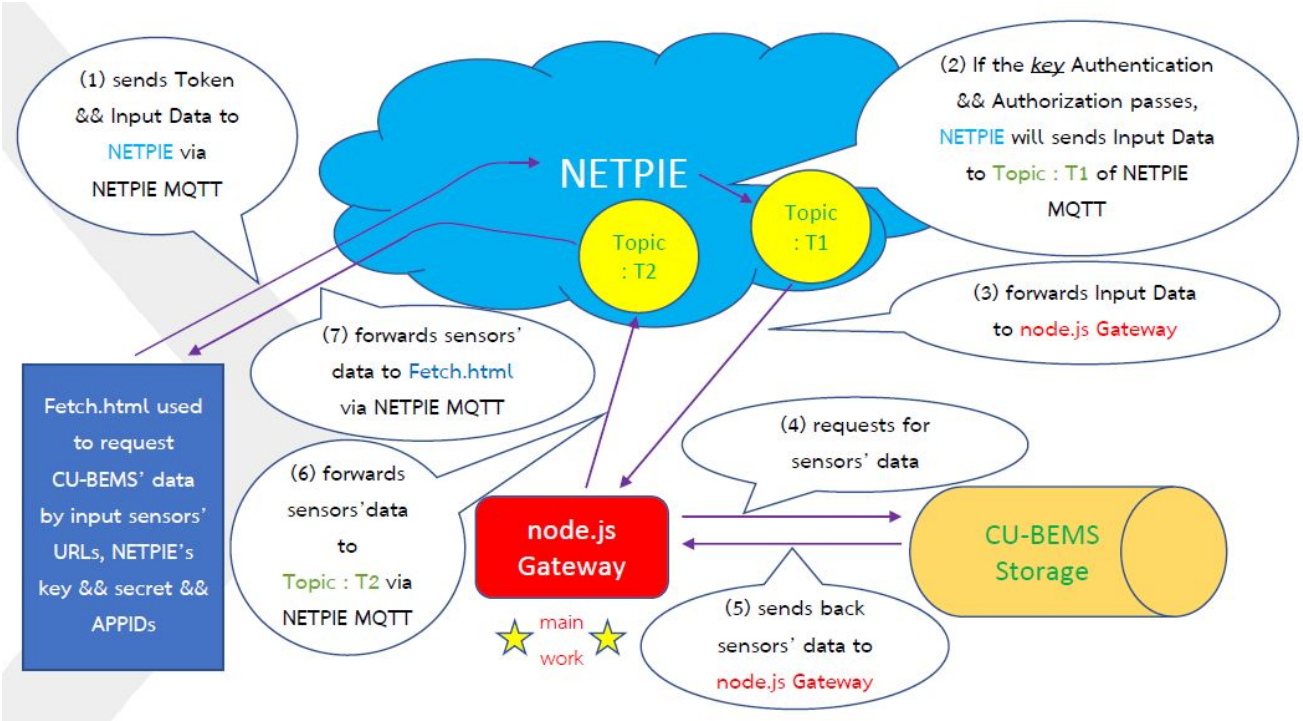
There are some sensors' URLs which can specify people in a room.

If there is no authentication to access, anyone can access CUBEMS storage.

Receiving only PIR sensor data can tell whether there is anyone in the room !

Solve : Use NETPIE security mechanisms to prevent an unauthorized access

Security Awareness (2) : NETPIE



Wasted Energy (1) : Importance

Nowadays, many people consume electrical energy without awareness.

That results in enormous wasted energy and unnecessary costs.

You can check real-time wasted energy data fetched via NETPIE secured channel from this demo :

http://smartgatewayweb.parallelcomputingdemo.161.200.90.110.xip.io/fetch.html

If people know the real-time value, this will increase energy usage awareness.

Total Wasted Energy from 1 Mar 2016 to 28 Feb 2017

Engineering 4 Building	Air-Conditioning System Wasted Energy (kWh)	Wasted Energy Costs (Baht)
Server Room	19402	108262
Telecommunication Technology Center	17307	96571
PSRL Laboratory	2434	13581
Staff Room 1	1219	6800
Coffee Room	1162	6486
Telecommunication Office	1038	5790
Telecommunication Laboratory	1000	5580

Engineering 4 Building	Air-Conditioning System Wasted Energy (kWh)	Wasted Energy Costs (Baht)
DSP Classroom	999	5574
Classroom 2	954	5321
Staff Room 2	500	2791
Staff Room 3	418	2333
PSRL Classroom	414	2311
Telecommunication Meeting Room	408	2278

From : "Chooputtipong, K., and Aswakul, C. Development of data analytic program for building energy management system with wasted energy analysis using motion sensor. The 39th Electrical Engineering Conference (EECON-39), Phetchaburi City, Thailand, 2016"

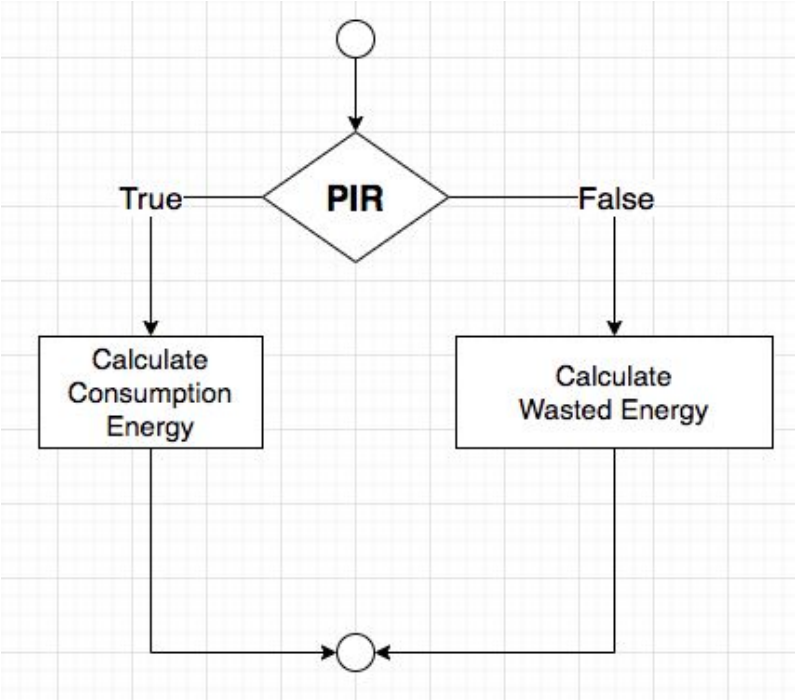
Total Wasted Energy from 1 Mar 2016 to 28 Feb 2017

Engineering 4 Building	Air-Conditioning System Wasted Energy (kWh)	Wasted Energy Costs (Baht)
Staff Room 4	406	2264
Staff Room 5	366	2040
Staff Room 6	365	2038
Staff Room 7	293	1638
Staff Room 8	174	972
AIS Laboratory	174	968
Staff Room 9	143	796
Staff Meeting Room	116	647

Engineering 4 Building	Air-Conditioning System Wasted Energy (kWh)	Wasted Energy Costs (Baht)
Staff Room 10	104	581
Studio Laboratory	67	374
Staff Room 11	62	344
Staff Room 12	45	252
CSBL Laboratory	30	170
Staff Room 13	10	55
Staff Room 14	2	14
Staff Room 15	0	1
Total	49611	276831

From : "Chooputtipong, K., and Aswakul, C. Development of data analytic program for building energy management system with wasted energy analysis using motion sensor. The 39th Electrical Engineering Conference (EECON-39), Phetchaburi City, Thailand, 2016"

Wasted Energy (2) : Calculation



PIR : Person in Room ?

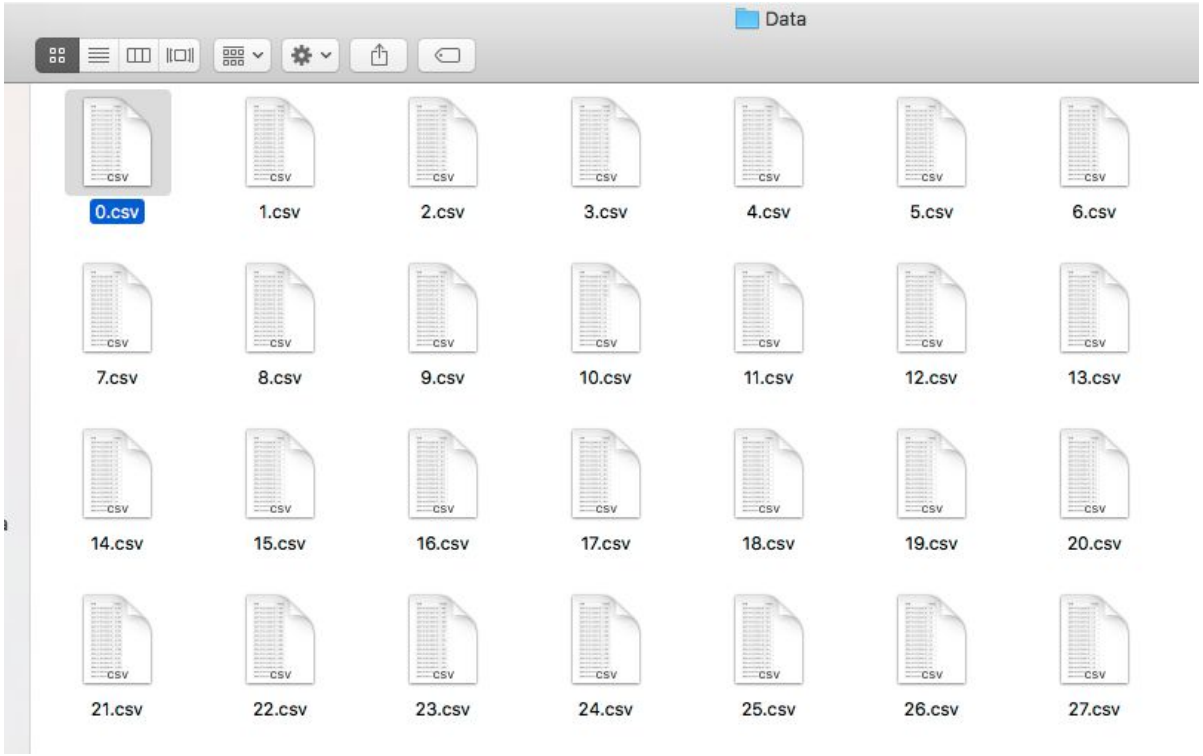
If PIR status is OFF and there is an energy usage, that means wasted energy occurs.

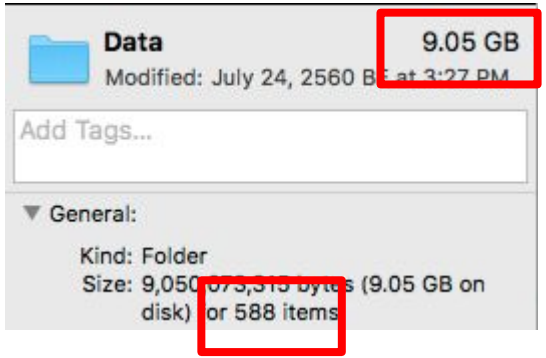
Sensor Data (now)


```
{
  "ee-fl1-corridor-elevator_front-z1-light1-monitor": {
      "type": "energy",
      "date": "2020-09-03T13:48:00.000+07:00",
      "value": "0.004",
      "floor": "fl1"
  },
  "ee-fl1-corridor-elevator_front-z1-outlet1-monitor": {
      "type": "energy",
      "date": "2020-09-03T13:48:00.000+07:00",
      "value": "1.698",
      "floor": "fl1"
  },
  "ee-fl1-corridor-walkingpath-z1-outlet1-monitor": {
      "type": "energy",
      "date": "2020-09-03T13:48:00.000+07:00",
      "value": "1.034",
      "floor": "fl1"
  },
```


- Try: http://newwebserver.parallelcomputingdemo.161.200.90.110.xip.io/now

Log Structure Analysis





ID	Sensor
19	http://bems.ee.eng.chula.ac.th/eng4/fl13/north/lab_tsrl_dsprl_emrl/z1/sensor4/monitor/pir
20	http://bems.ee.eng.chula.ac.th/eng4/fl13/north/lab_tsrl_dsprl_emrl/z1/sensor4/monitor/temperature
21	http://bems.ee.eng.chula.ac.th/eng4/fl13/north/lab_tsrl_dsprl_emrl/z2/aircon1/monitor/energy
22	http://bems.ee.eng.chula.ac.th/eng4/fl13/north/lab_tsrl_dsprl_emrl/z2/light1/monitor/energy
23	http://bems.ee.eng.chula.ac.th/eng4/fl13/north/lab_tsrl_dsprl_emrl/z2/light2/monitor/energy
24	http://bems.ee.eng.chula.ac.th/eng4/fl13/north/lab_tsrl_dsprl_emrl/z2/outlet1/monitor/energy
25	http://bems.ee.eng.chula.ac.th/eng4/fl13/north/lab_tsrl_dsprl_emrl/z2/sensor1/monitor/humidity
26	http://bems.ee.eng.chula.ac.th/eng4/fl13/north/lab_tsrl_dsprl_emrl/z2/sensor1/monitor/illuminance
27	http://bems.ee.eng.chula.ac.th/eng4/fl13/north/lab_tsrl_dsprl_emrl/z2/sensor1/monitor/pir
28	http://bems.ee.eng.chula.ac.th/eng4/fl13/north/lab_tsrl_dsprl_emrl/z2/sensor1/monitor/temperature

Data of PIR and Zone

Zone	PIR - Point-id
eng4-fl13-north-lab_tsrl_dsprl_emrl-z1	19
eng4-fl13-north-lab_tsrl_dsprl_emrl-z2	35
eng4-fl13-north-lab_tsrl_dsprl_emrl-z3	47
eng4-fl13-north-lab_tsrl_dsprl_emrl-z4	60
eng4-fl13-north-lab_tsrl_dsprl_emrl-z5	72
eng4-fl13-north-lab_tsrl_dsprl_emrl-z6	85

19.csv

```
1  TIME,VALUE
2  2014-04-15 20:40:16,0.0
3  2014-04-15 20:40:45,1.0
4  2014-04-15 20:41:14,1.0
5  2014-04-15 20:41:43,0.0
6  2014-04-15 20:42:13,0.0
7  2014-04-15 20:42:42,0.0
8  2014-04-15 20:43:11,0.0
9  2014-04-15 20:43:41,0.0
10 2014-04-15 20:44:10,0.0
11 2014-04-15 20:44:40,0.0
12 2014-04-15 20:45:09,0.0
13 2014-04-15 20:45:39,0.0
14 2014-04-15 20:46:08,0.0
```

19.csv Info

19.csv 14.9 MB
Modified: Aug 21, 2560 BE, 2:20 AM

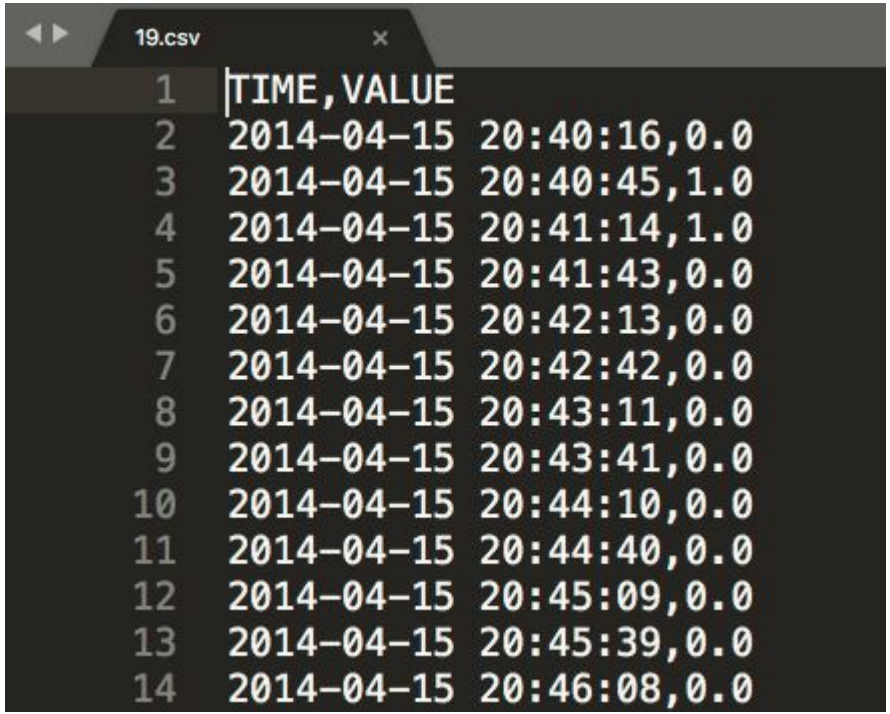
Add Tags...

General:

Kind: CSV Documen
Size: 14,901,749 bytes (14.9 MB on disk)

19.csv

```
598220 2017-08-20
598221 2017-08-20
598222 2017-08-20
598223 2017-08-20 23:48:57,OFF
598224 2017-08-20 23:49:55,OFF
598225 2017-08-20 23:50:54,OFF
598226 2017-08-20 23:51:53,OFF
598227 2017-08-20 23:52:51,OFF
598228 2017-08-20 23:53:50,OFF
598229 2017-08-20 23:54:49,OFF
598230 2017-08-20 23:55:47,OFF
598231 2017-08-20 23:58:43,OFF
598232
```



Possible Values	Person in room
0.0 or OFF	False
1.0 or ON	True

```
{
  'eng4-fl13-north-lab_tsrl_dsprl_emrl-z1': { pir: '19',
  'eng4-fl13-north-lab_tsrl_dsprl_emrl-z2': { pir: '35', energy: [] },
  'eng4-fl13-north-lab_tsrl_dsprl_emrl-z3': { pir: '47', energy: [] },
  'eng4-fl13-north-lab_tsrl_dsprl_emrl-z4': { pir: '60', energy: [] },
  'eng4-fl13-north-lab_tsrl_dsprl_emrl-z5': { pir: '72', energy: [] },
  'eng4-fl13-north-lab_tsrl_dsprl_emrl-z6': { pir: '85', energy: [] },
  'eng4-fl13-north-lab_tsrl_dsprl_emrl-z7': { pir: '108', energy: [] },
  'eng4-fl13-north-lab_tsrl_dsprl_emrl-z8': { pir: '129', energy: [] },
  'eng4-fl13-corridor-elevetorfront-z1': { pir: '137', energy: [] },
  'eng4-fl13-corridor-walkingpath-z1': { pir: '150', energy: [] },
  'eng4-fl13-north-lab_cu_ais_rf_rtl-z1': { pir: '163', energy: [] },
  'eng4-fl13-north-lab_studio-z1': { pir: '167', energy: [] },
  'eng4-fl13-north-lab_telecommunication-z1': { pir: '172', energy: [] },
  'eng4-fl13-north-room_pantry-z1': { pir: '178', energy: [] },
  'eng4-fl13-north-room_server-z1': { pir: '189', energy: [] },
```

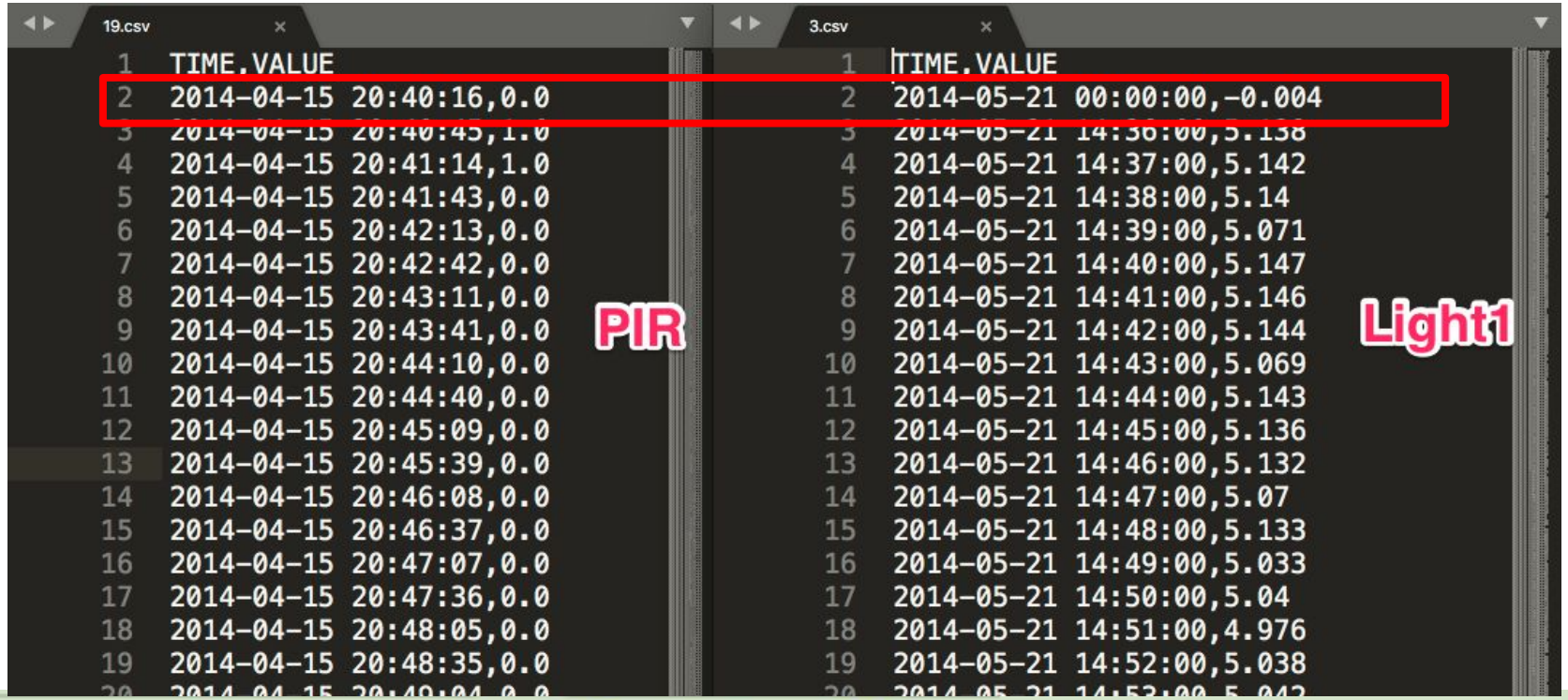
Point ID

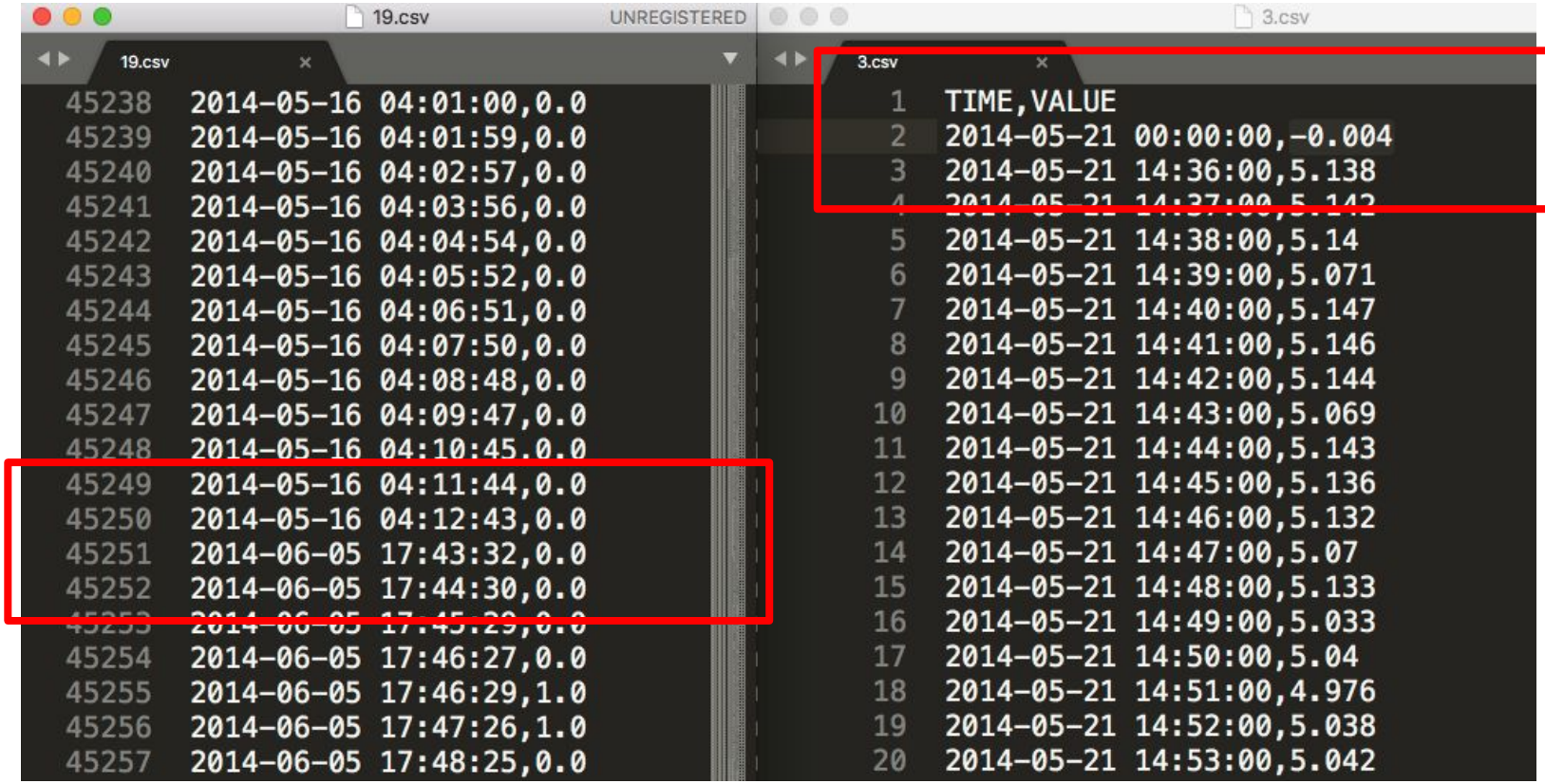
Structure

```
{
 'eng4-fl13-north-lab_tsrl_dsprl_emrl-z1': { pir: '19', energy: [ '3', '4' ] },
 'eng4-fl13-north-lab_tsrl_dsprl_emrl-z2': { pir: '35', energy: [ '21', '22', '23', '24' ] },
 'eng4-fl13-north-lab_tsrl_dsprl_emrl-z3': { pir: '47', energy: [ '40' ] },
 'eng4-fl13-north-lab_tsrl_dsprl_emrl-z4': { pir: '60', energy: [ '52', '53' ] },
 'eng4-fl13-north-lab_tsrl_dsprl_emrl-z5': { pir: '72', energy: [ '65' ] },
 'eng4-fl13-north-lab_tsrl_dsprl_emrl-z6': { pir: '85', energy: [ '77', '78' ] },
 'eng4-fl13-north-lab_tsrl_dsprl_emrl-z7': { pir: '108', energy: [ '90', '91', '92', '93' ] },
 'eng4-fl13-north-lab_tsrl_dsprl_emrl-z8': { pir: '129', energy: [ '113', '114' ] },
 'eng4-fl13-corridor-elevetorfront-z1': { pir: '137', energy: [] },
 'eng4-fl13-corridor-walkingpath-z1': { pir: '150', energy: [ '139' ] },
 'eng4-fl13-north-lab_cu_ais_rf_rtl-z1': { pir: '163', energy: [ '160' ] },
  ["0", "eng4", "fl13", "north", "lab_tsrl_dsprl_emrl", "z1", "aircon_3ph1", "monitor", "energy_r"],
  ["1", "eng4", "fl13", "north", "lab_tsrl_dsprl_emrl", "z1", "aircon_3ph1", "monitor", "energy_s"],
  ["2", "eng4", "fl13", "north", "lab_tsrl_dsprl_emrl", "z1", "aircon_3ph1", "monitor", "energy_t"],
  ["3", "eng4", "fl13", "north", "lab_tsrl_dsprl_emrl", "z1", "light1", "monitor", "energy"],
  ["4", "eng4", "fl13", "north", "lab_tsrl_dsprl_emrl", "z1", "outlet1", "monitor", "energy"],
  ["5", "eng4", "fl13", "north", "lab_tsrl_dsprl_emrl", "z1", "sensor1", "monitor", "humidity"],
  ["6", "eng4", "fl13", "north", "lab_tsrl_dsprl_emrl", "z1", "sensor1", "monitor", "illuminance"],
  ["7", "eng4", "fl13", "north", "lab_tsrl_dsprl_emrl", "z1", "sensor1", "monitor", "pir"],
  ["8", "eng4", "fl13", "north", "lab_tsrl_dsprl_emrl", "z1", "sensor1", "monitor", "temperature"],
```

Energy Consumption

Timestamp matching in each minute



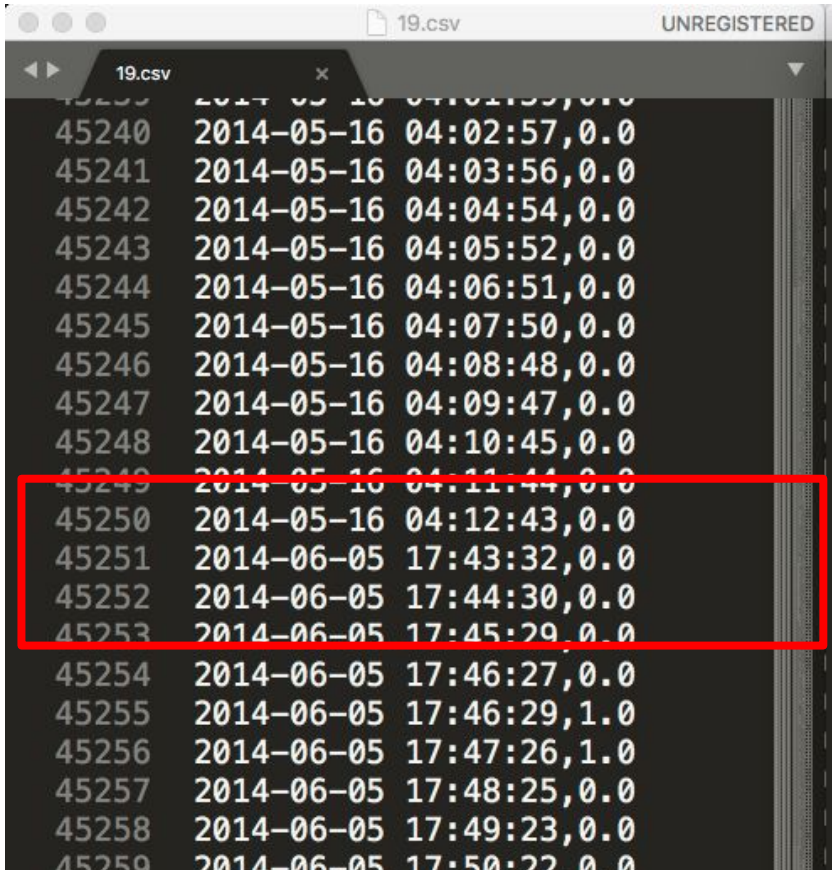


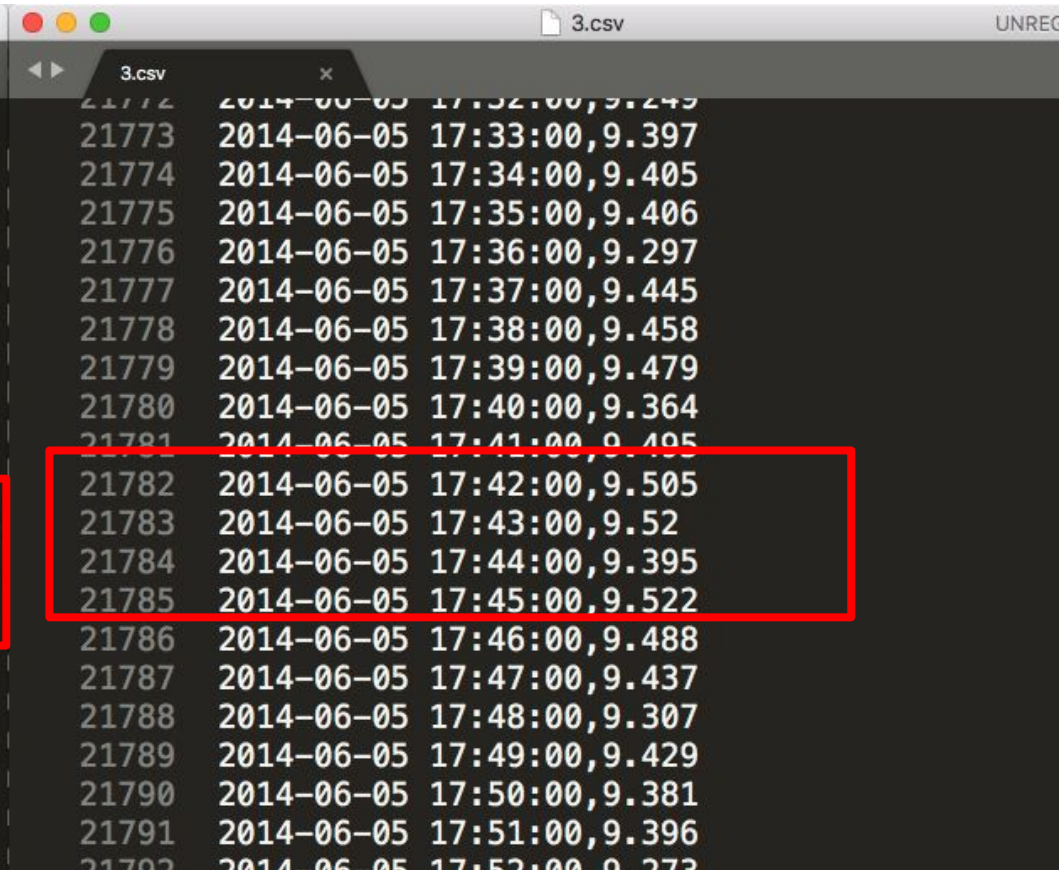
19.csv UNREGISTERED

```
45238  2014-05-16 04:01:00,0.0
45239  2014-05-16 04:01:59,0.0
45240  2014-05-16 04:02:57,0.0
45241  2014-05-16 04:03:56,0.0
45242  2014-05-16 04:04:54,0.0
45243  2014-05-16 04:05:52,0.0
45244  2014-05-16 04:06:51,0.0
45245  2014-05-16 04:07:50,0.0
45246  2014-05-16 04:08:48,0.0
45247  2014-05-16 04:09:47,0.0
45248  2014-05-16 04:10:45,0.0
45249  2014-05-16 04:11:44,0.0
45250  2014-05-16 04:12:43,0.0
45251  2014-06-05 17:43:32,0.0
45252  2014-06-05 17:44:30,0.0
45254  2014-06-05 17:46:27,0.0
45255  2014-06-05 17:46:29,1.0
45256  2014-06-05 17:47:26,1.0
45257  2014-06-05 17:48:25,0.0
```

3.csv

```
1  TIME,VALUE
2  2014-05-21 00:00:00,-0.004
3  2014-05-21 14:36:00,5.138
5  2014-05-21 14:38:00,5.14
6  2014-05-21 14:39:00,5.071
7  2014-05-21 14:40:00,5.147
8  2014-05-21 14:41:00,5.146
9  2014-05-21 14:42:00,5.144
10 2014-05-21 14:43:00,5.069
11 2014-05-21 14:44:00,5.143
12 2014-05-21 14:45:00,5.136
13 2014-05-21 14:46:00,5.132
14 2014-05-21 14:47:00,5.07
15 2014-05-21 14:48:00,5.133
16 2014-05-21 14:49:00,5.033
17 2014-05-21 14:50:00,5.04
18 2014-05-21 14:51:00,4.976
19 2014-05-21 14:52:00,5.038
20 2014-05-21 14:53:00,5.042
```


19.csv
UNREGISTERED
19.csv
45240 2014-05-16 04:02:57,0.0
45241 2014-05-16 04:03:56,0.0
45242 2014-05-16 04:04:54,0.0
45243 2014-05-16 04:05:52,0.0
45244 2014-05-16 04:06:51,0.0
45245 2014-05-16 04:07:50,0.0
45246 2014-05-16 04:08:48,0.0
45247 2014-05-16 04:09:47,0.0
45248 2014-05-16 04:10:45,0.0
45250 2014-05-16 04:12:43,0.0
45251 2014-06-05 17:43:32,0.0
45252 2014-06-05 17:44:30,0.0
45254 2014-06-05 17:46:27,0.0
45255 2014-06-05 17:46:29,1.0
45256 2014-06-05 17:47:26,1.0
45257 2014-06-05 17:48:25,0.0
45258 2014-06-05 17:49:23,0.0


3.csv
UNREC
3.csv
21773 2014-06-05 17:33:00,9.397
21774 2014-06-05 17:34:00,9.405
21775 2014-06-05 17:35:00,9.406
21776 2014-06-05 17:36:00,9.297
21777 2014-06-05 17:37:00,9.445
21778 2014-06-05 17:38:00,9.458
21779 2014-06-05 17:39:00,9.479
21780 2014-06-05 17:40:00,9.364
21782 2014-06-05 17:42:00,9.505
21783 2014-06-05 17:43:00,9.52
21784 2014-06-05 17:44:00,9.395
21785 2014-06-05 17:45:00,9.522
21786 2014-06-05 17:46:00,9.488
21787 2014-06-05 17:47:00,9.437
21788 2014-06-05 17:48:00,9.307
21789 2014-06-05 17:49:00,9.429
21790 2014-06-05 17:50:00,9.381
21791 2014-06-05 17:51:00,9.396

```
{
  'eng4-fl13-north-lab_tsrl_dsprl_emrl-z1': { pir: '19', energy: [ '3', '4' ] },
  'eng4-fl13-north-lab_tsrl_dsprl_emrl-z2': { pir: '35', energy: [ '21', '22', '23', '24' ] },
  'eng4-fl13-north-lab_tsrl_dsprl_emrl-z3': { pir: '47', energy: [ '40' ] },
  'eng4-fl13-north-lab_tsrl_dsprl_emrl-z4': { pir: '60', energy: [ '52', '53' ] },
  'eng4-fl13-north-lab_tsrl_dsprl_emrl-z5': { pir: '72', energy: [ '65' ] },
  'eng4-fl13-north-lab_tsrl_dsprl_emrl-z6': { pir: '85', energy: [ '77', '78' ] },
  'eng4-fl13-north-lab_tsrl_dsprl_emrl-z7': { pir: '108', energy: [ '90', '91', '92', '93' ] },
  'eng4-fl13-north-lab_tsrl_dsprl_emrl-z8': { pir: '129', energy: [ '113', '114' ] },
  'eng4-fl13-corridor-elevetorfront-z1': { pir: '137', energy: [] },
  'eng4-fl13-corridor-walkingpath-z1': { pir: '150', energy: [ '139' ] },
  'eng4-fl13-north-lab_cu_ais_rf_rtl-z1': { pir: '163', energy: [ '160' ] },
  'eng4-fl13-north-lab_studio-z1': { pir: '167', energy: [] },
  'eng4-fl13-north-lab_telecommunication-z1': { pir: '172', energy: [ '169' ] },
  'eng4-fl13-north-room_pantry-z1': { pir: '178', energy: [ '174', '175' ] },
  'eng4-fl13-north-room_server-z1': {
```

3th IoTcloudServe@TEIN Collaboration Community Meeting

```
Benzs-iMac:Parallel computing running on Kubern
[
  { pirpointid: '19', energypointid: '3' },
  { pirpointid: '19', energypointid: '4' },
  { pirpointid: '35', energypointid: '21' },
  { pirpointid: '35', energypointid: '22' },
  { pirpointid: '35', energypointid: '23' },
  { pirpointid: '35', energypointid: '24' },
  { pirpointid: '47', energypointid: '40' },
  { pirpointid: '60', energypointid: '52' },
  { pirpointid: '60', energypointid: '53' },
  { pirpointid: '72', energypointid: '65' },
  { pirpointid: '85', energypointid: '77' },
  { pirpointid: '85', energypointid: '78' },
  { pirpointid: '108', energypointid: '90' },
  { pirpointid: '108', energypointid: '91' },
  { pirpointid: '108', energypointid: '92' },
  { pirpointid: '108', energypointid: '93' },
  { pirpointid: '129', energypointid: '113' },
  { pirpointid: '129', energypointid: '114' },
```

```
  { pirpointid: '550', energypointid: '544' },
  { pirpointid: '550', energypointid: '545' },
  { pirpointid: '550', energypointid: '546' },
  { pirpointid: '550', energypointid: '547' },
  { pirpointid: '557', energypointid: '552' },
  { pirpointid: '557', energypointid: '553' },
  { pirpointid: '557', energypointid: '554' },
  { pirpointid: '563', energypointid: '559' },
  { pirpointid: '563', energypointid: '560' },
  { pirpointid: '572', energypointid: '567' },
  { pirpointid: '572', energypointid: '568' },
  { pirpointid: '572', energypointid: '569' },
  { pirpointid: '577', energypointid: '574' },
  { pirpointid: '583', energypointid: '579' },
  { pirpointid: '583', energypointid: '580' }
]
#jobs: 96
```

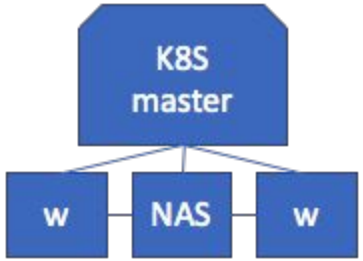
Define a service as a web server.

Containerize

Containerize the service to run on any K8S

Deploy

IoTcloudServe@TEIN



Deploy the container in K8S

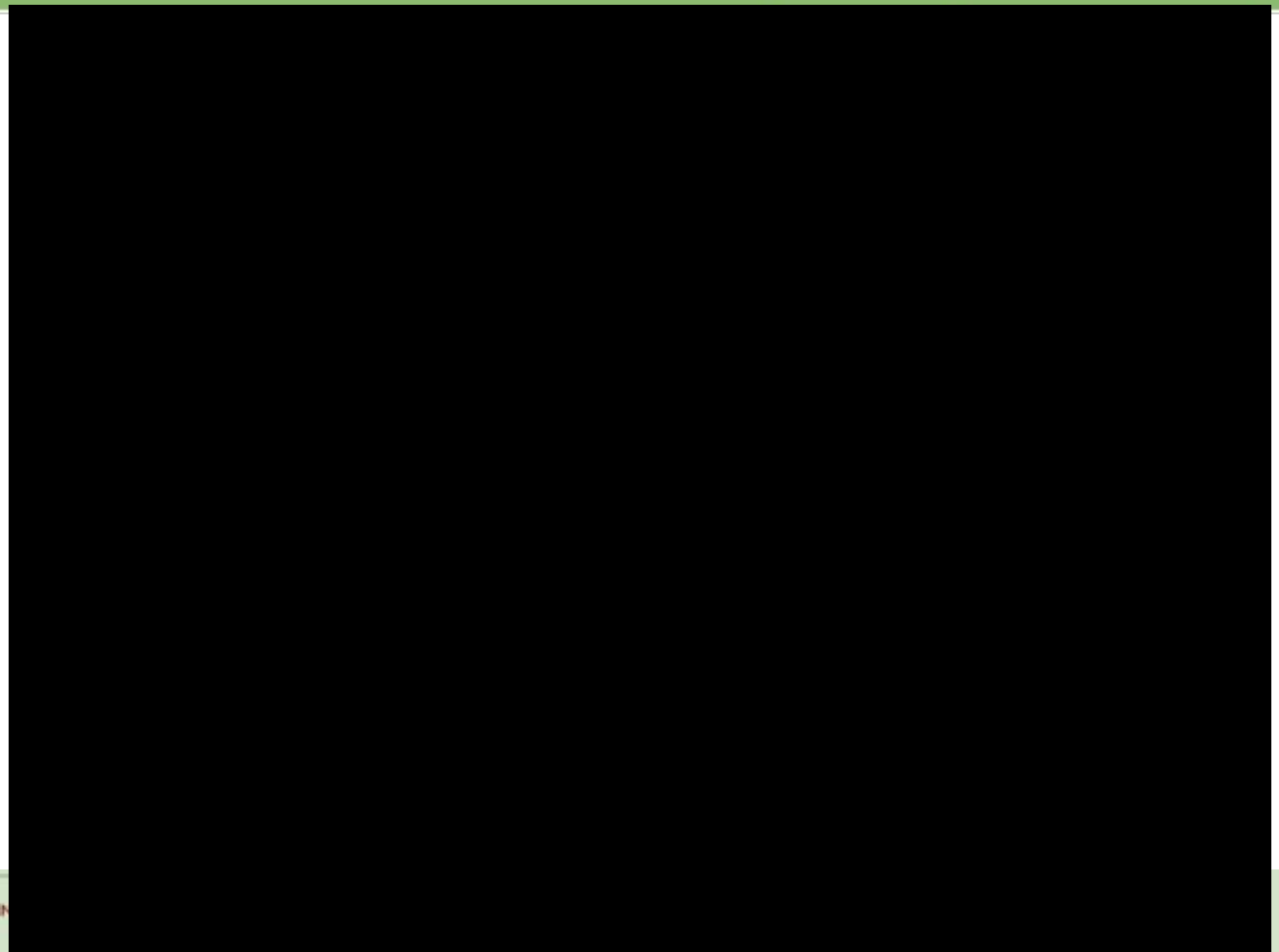
The container can be scaled up as a "pod".

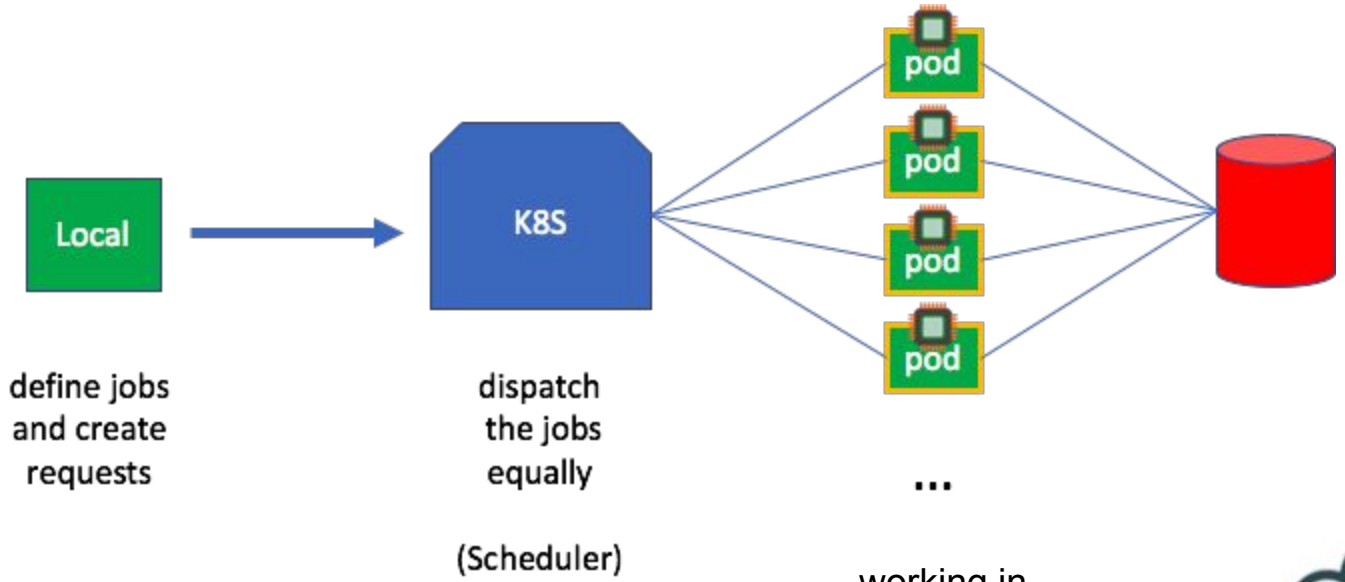
...

IoT cloudserve @TEIN

Scale up the processing power (video)

☐	Running	webserver-64ff75b694-zpxfs	quay.io/paragon/smartscheduler 10.42.2.177 / Created 2 hours ago / Restarts: 0	k3os-22851 202.28.193.100
☐	Running	webserver-64ff75b694-w4j76	quay.io/paragon/smartscheduler 10.42.2.175 / Created 2 hours ago / Restarts: 0	k3os-22851 202.28.193.100
☐	Running	webserver-64ff75b694-vqn67	quay.io/paragon/smartscheduler 10.42.2.186 / Created 2 hours ago / Restarts: 0	k3os-22851 202.28.193.100
☐	Running	webserver-64ff75b694-tvldf	quay.io/paragon/smartscheduler 10.42.2.170 / Created 2 hours ago / Restarts: 0	k3os-22851 202.28.193.100
☐	Running	webserver-64ff75b694-tcz7r	quay.io/paragon/smartscheduler 10.42.2.171 / Created 2 hours ago / Restarts: 0	k3os-22851 202.28.193.100
☐	Running	webserver-64ff75b694-t4mrn	quay.io/paragon/smartscheduler 10.42.2.195 / Created a few seconds ago / Restarts: 0	k3os-22851 202.28.193.100
☐	Running	webserver-64ff75b694-t28tc	quay.io/paragon/smartscheduler 10.42.2.192 / Created 2 hours ago / Restarts: 0	k3os-22851 202.28.193.100

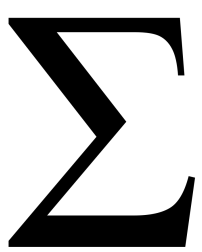



Local
K8S
pod
pod
pod
pod
...
define jobs and create requests
dispatch the jobs equally
(Scheduler)
working in parallel

```
Benzs-iMac:Parallel computing running on Kubern
[
  { pirpointid: '19', energypointid: '3' },
  { pirpointid: '19', energypointid: '4' },
  { pirpointid: '35', energypointid: '21' },
  { pirpointid: '35', energypointid: '22' },
  { pirpointid: '35', energypointid: '23' },
  { pirpointid: '35', energypointid: '24' },
  { pirpointid: '47', energypointid: '40' },
  { pirpointid: '60', energypointid: '52' },
  { pirpointid: '60', energypointid: '53' },
  { pirpointid: '72', energypointid: '65' },
  { pirpointid: '85', energypointid: '77' },
  { pirpointid: '85', energypointid: '78' },
  { pirpointid: '108', energypointid: '90' },
  { pirpointid: '108', energypointid: '91' },
  { pirpointid: '108', energypointid: '92' },
  { pirpointid: '108', energypointid: '93' },
  { pirpointid: '129', energypointid: '113' },
  { pirpointid: '129', energypointid: '114' },
```

Filter Date with PIR ⇨ Match with the logs ⇨ Calculate Energy Consumption

PIR pointid 19.csv * Light1 pointid 3.csv =



PIR pointid 19.csv	*	Light1 pointid 3.csv	=	
PIR pointid 19.csv	*	Outlet1 pointid 4.csv	=	
PIR pointid 35.csv	*	**aircon** pointid 21.csv	=	
PIR pointid 35.csv	*	**light2** pointid 23.csv	=	

...

Not Secure | newwebserver.parallelcompu

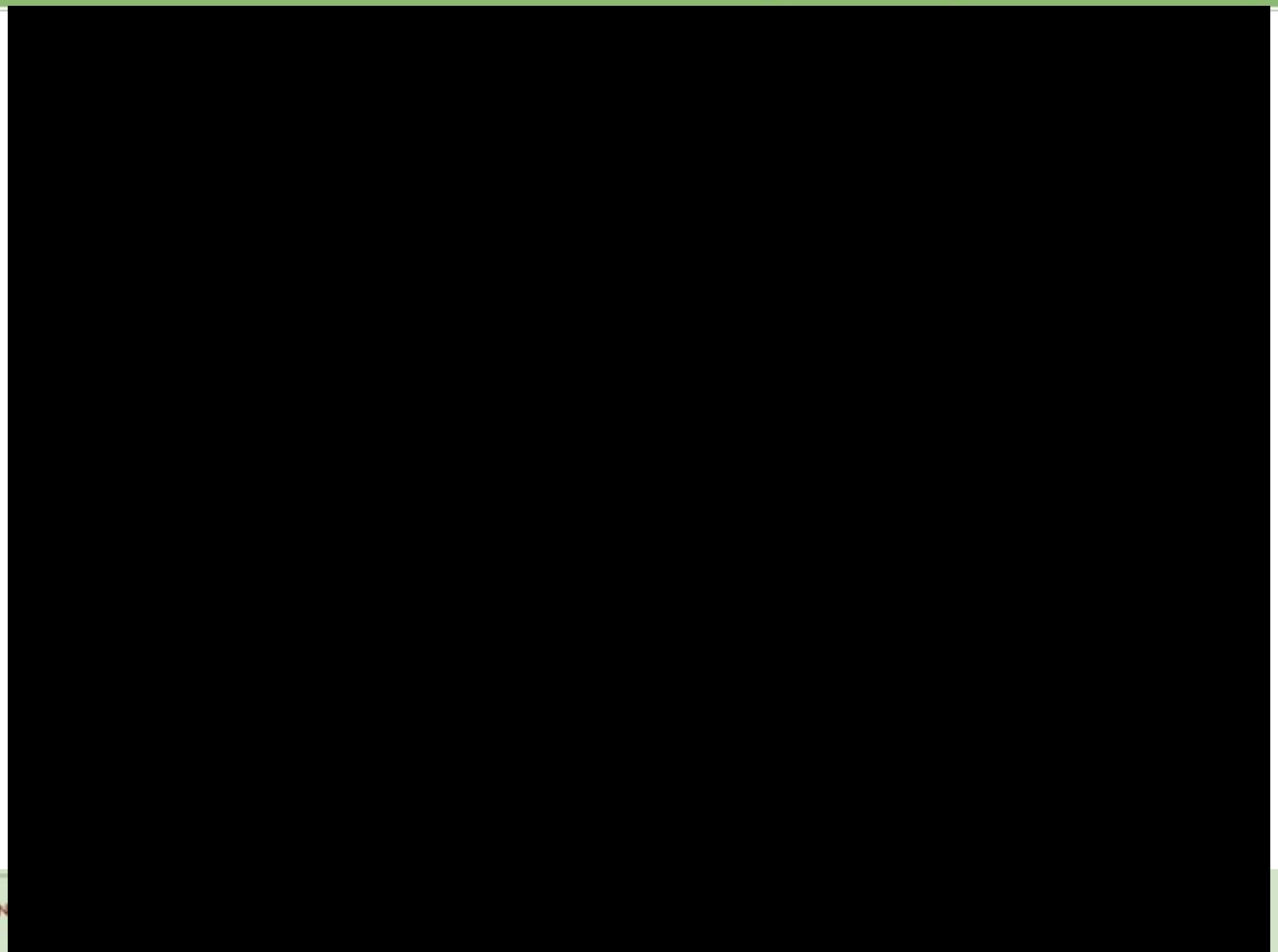
```
{
    "allenergy": 404749.9289998987,
    "wastedenergy": 284149.859999917,
    "usefulenergy": 120600.06900000013
}
```

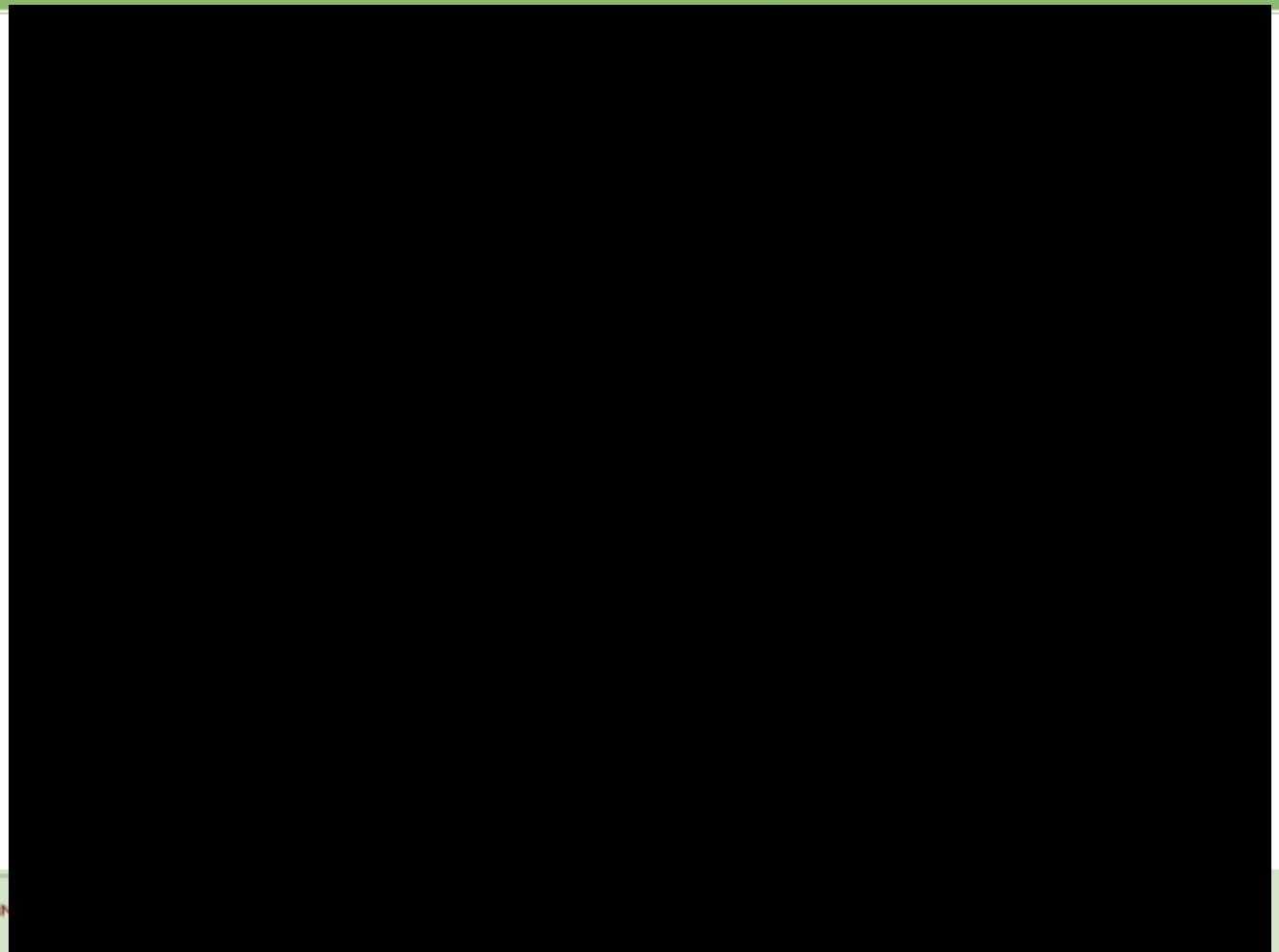
kWh

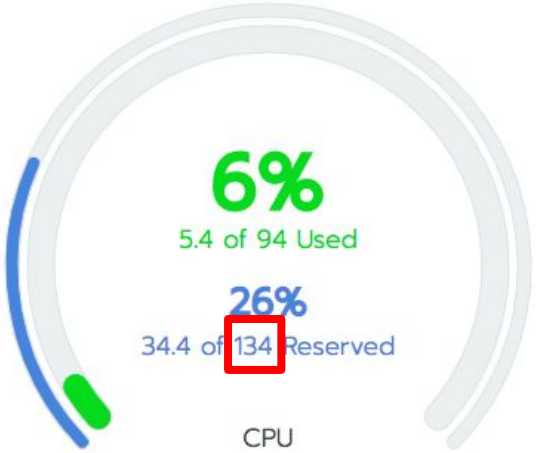
```
{
    "allenergy": 327834.9699999993,
    "wastedenergy": 287646.3739999978,
    "usefulenergy": 40188.59599999987
}
```

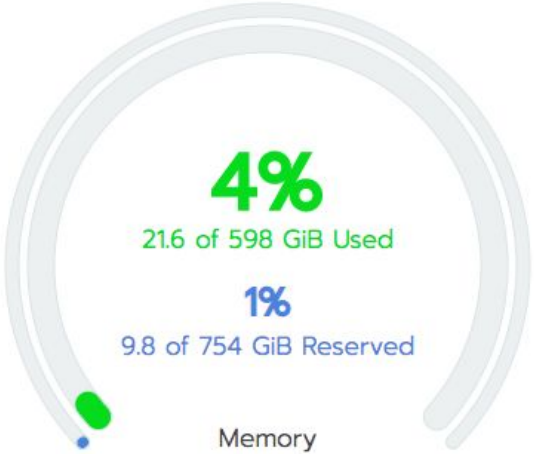
```
{
    "allenergy": 3523017.026000337,
    "wastedenergy": 3103886.088000283,
    "usefulenergy": 419130.9380000026
}
```

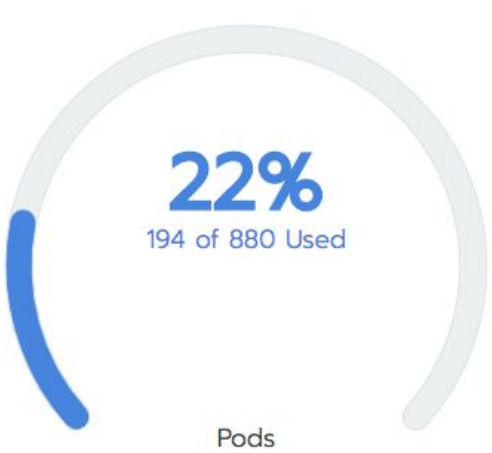
```
{
    "allenergy": 1176862.1469989454,
    "wastedenergy": 1029571.6500004458,
    "usefulenergy": 147290.49699999974
}
```



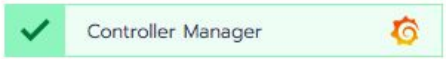



6%
5.4 of 94 Used
26%
34.4 of 134 Reserved
CPU


4%
21.6 of 598 GiB Used
1%
9.8 of 754 GiB Reserved
Memory


22%
194 of 880 Used
Pods


Etcd


Controller Manager


Scheduler


Nodes

Q&A

Thank you