



# A DYNAMIC PRICING DEMAND RESPONSE ALGORITHM FOR THE SMART GRID

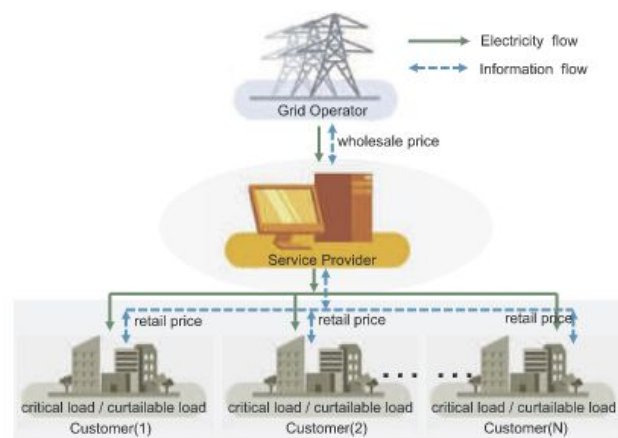
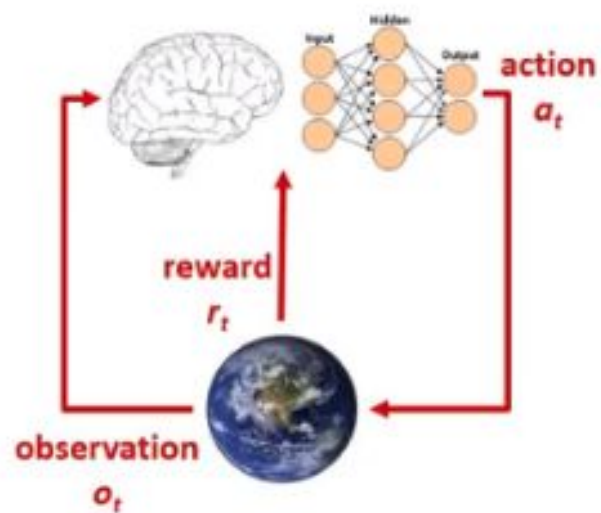
## THE REINFORCEMENT LEARNING APPROACH

IERG 4999R

FINAL YEAR PROJECT II

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## FROM SEMESTER ONE...

- The Electricity Market Model in U.S.
- How reinforcement learning works
- Re-establish the paper and test the result

# PROBLEM STATEMENTS

$$\max \sum_{n=1}^N \sum_{t=1}^T [\rho \cdot (\lambda_{t,n} - \pi_t) \cdot e_{t,n} - (1 - \rho) \cdot (\lambda_{t,n} \cdot e_{t,n} + \varphi_{t,n})]$$

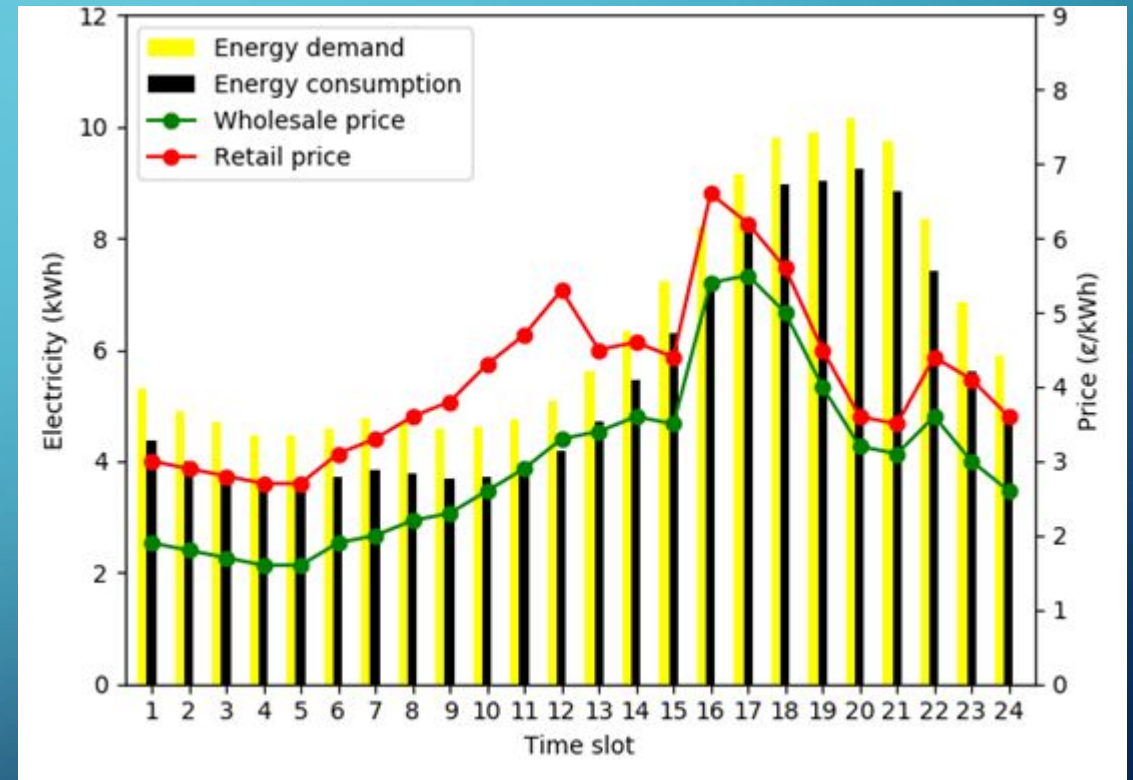
$$\min \sum_{t=1}^T [\lambda_{t,n} \cdot (e_{t,n}^{curt} + e_{t,n}^{critic}) + \varphi_{t,n}]$$

$$\max \sum_{n=1}^N \sum_{t=1}^T (\lambda_{t,n} - \pi_t) \cdot (e_{t,n}^{curt} + e_{t,n}^{critic})$$

$$e_{t,n}^{curt} = E_{t,n}^{curt} \cdot \left( 1 + \xi_t \cdot \frac{\lambda_{t,n} - \pi_t}{\pi_t} \right)$$

$$e_{t,n}^{critic} = E_{t,n}^{critic}$$

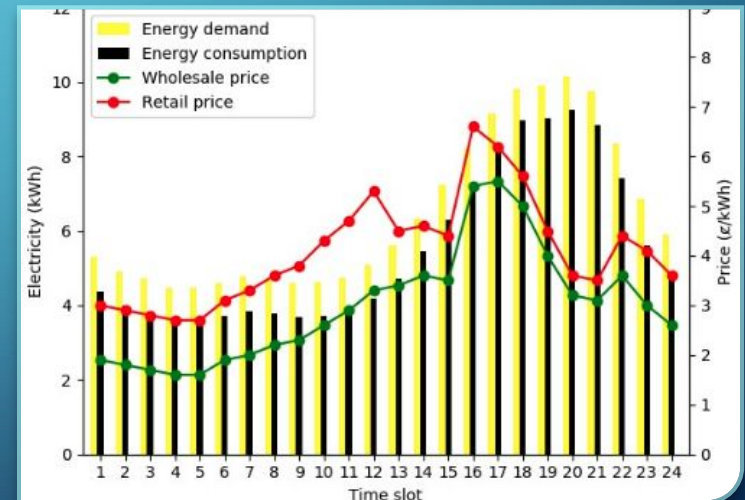
OR



## BUT WAIT, WHAT NEXT?

- How can the make use of the result?
- Is there anything we can further enhance?
- What about the real world situation to the problem we are aiming to solving?

```
3475; reward: -578.7350372110142.  
6032; reward: -578.7350372110142.  
82498; reward: -578.7350372110142.  
88479; reward: -578.7350372110142..  
953143; reward: -578.7350372110142.  
044593; reward: -578.7350372110142..  
0696065; reward: -578.7350372110142..  
839049; reward: -578.7350372110142...  
2171237; reward: -578.7350372110142...  
70267437; reward: -578.7350372110142...  
904916635; reward: -578.7350372110142...  
465742207; reward: -578.7350372110142...  
28545625; reward: -578.7350372110142...  
6096263796; reward: -578.7350372110142...  
000448760; reward: -578.7350372110142
```





# DATA SCIENCE

- It is about using data to create as much impact as possible for the problem that we want to solve.
- Did we solved the problem? -> Yes
- How can we manipulate so that it carries real world impact to a small point of view?
- To make the open source codes more sustainable and can be apply to the real world data.

# THE DATA SCIENCE **HIERARCHY OF NEEDS**

LEARN/OPTIMIZE

AGGREGATE/LABEL

EXPLORE/TRANSFORM

MOVE/STORE

COLLECT



# Our Solution = A Web Application

- A Data Visualization tool
- Update on daily basis
- Automated data entry process
- Automated program execution process



# MODERN SOFTWARE ENGINEERING

- Client-Side

- Data visualization
- Web-Scripting
- Data Analysis

- Server-Side

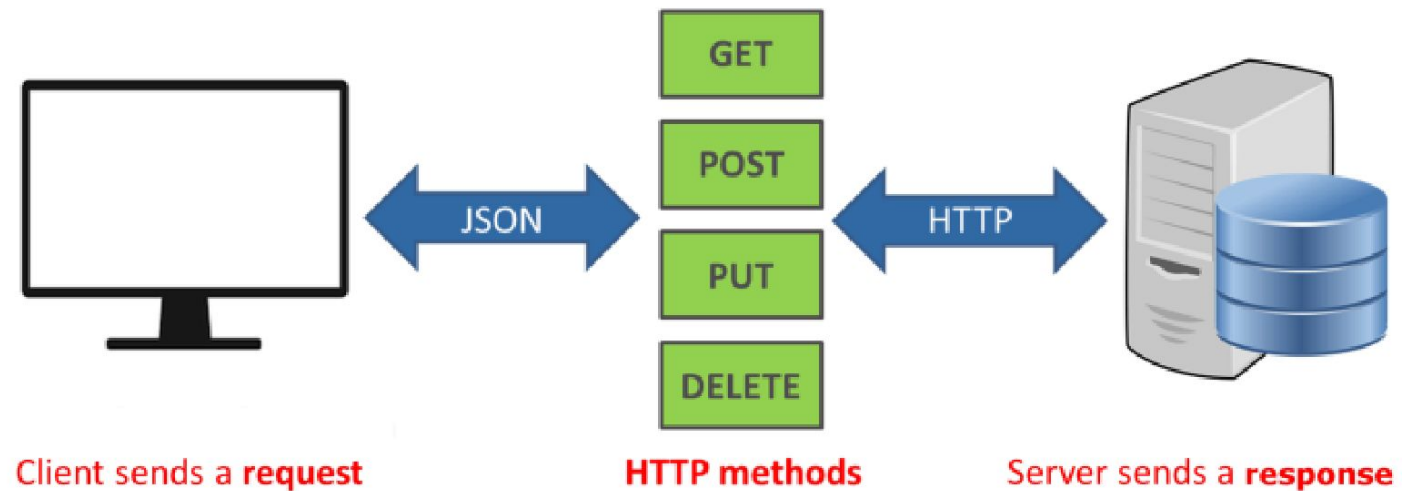
- Reinforcement Learning Calculation (Crontab)
- Data storing
- Data Pre-Processing Automation (ComEd API Call)





# WHAT IS RESTFUL API?

- A RESTful API is an application program interface that uses HTTP requests to GET, PUT, POST and DELETE data.



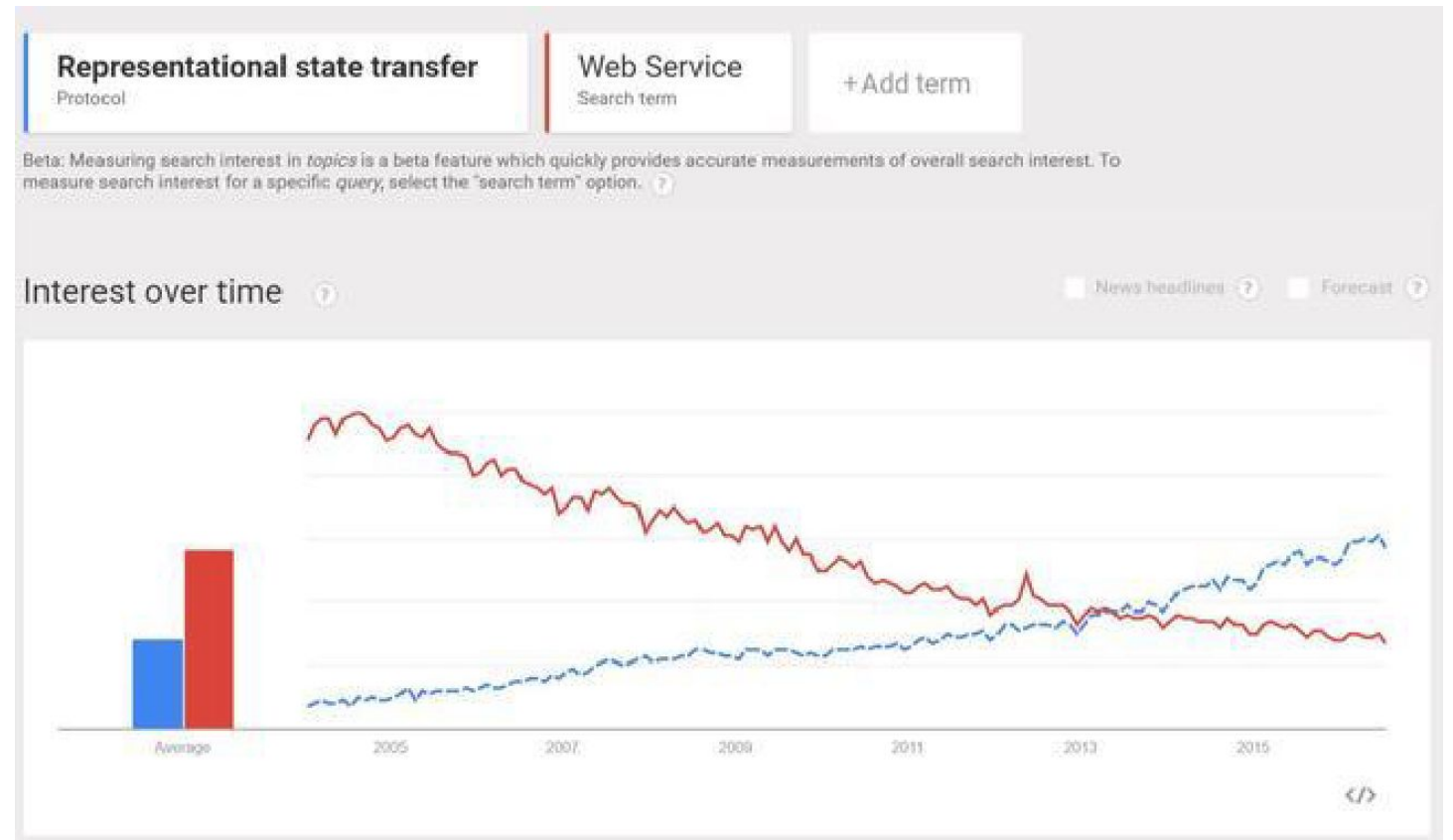
# WHY RESTFUL API

- Help us to get the data we want within a short period of time. directly exchange data in a simple way.



# WHY RESTFUL API

- Most companies are encouraging third parties to use them by disclosing their data sets.



## HOW RESTFUL API?

- It offer APIs of the 5-minute prices for ComEd's Hourly Pricing program. The APIs can be accessed at the following URLS.

**ComEd**

An Exelon Company

powering lives

### API: LAST 24 HOURS

Returns all 5-minute prices from the last 24 hours.

<https://hourlypricing.comed.com/api?type=5minutefeed>

### API: CUSTOM TIME RANGE

Returns 5-minute prices between the times provided, inclusively.

Example: [https://hourlypricing.comed.com/api?](https://hourlypricing.comed.com/api?type=5minutefeed&datestart=201506031105&dateend=201506031200)

[type=5minutefeed&datestart=201506031105&dateend=201506031200](https://hourlypricing.comed.com/api?type=5minutefeed&datestart=201506031105&dateend=201506031200)

Note: Times in bold are in the format: **YYYYMMDDhhmm** and should be changed to suit your custom parameters.



# LET'S SEE THE RESULT!

05/17/2020

▼ Array(48) ⓘ

```
0: "00:00"
1: 1.936363636363636
2: "01:00"
3: 2.018181818181818
4: "02:00"
5: 1.9909090909090912
6: "03:00"
7: 1.9363636363636372
8: "04:00"
9: 1.9090909090909098
10: "05:00"
11: 1.7363636363636368
12: "06:00"
```

Untitled Request

GET http://hourlypricing.comed.com/api?type=5minutefeed ...

Params Auth Headers (7) Body Pre-req. Tests Settings Cookies Code Status: 200 OK Time: 621 ms Size: 12.5 KB Save

KEY	VALUE	DESCRIPTION
<input checked="" type="checkbox"/> type	5minutefee	
Key	Value	Description

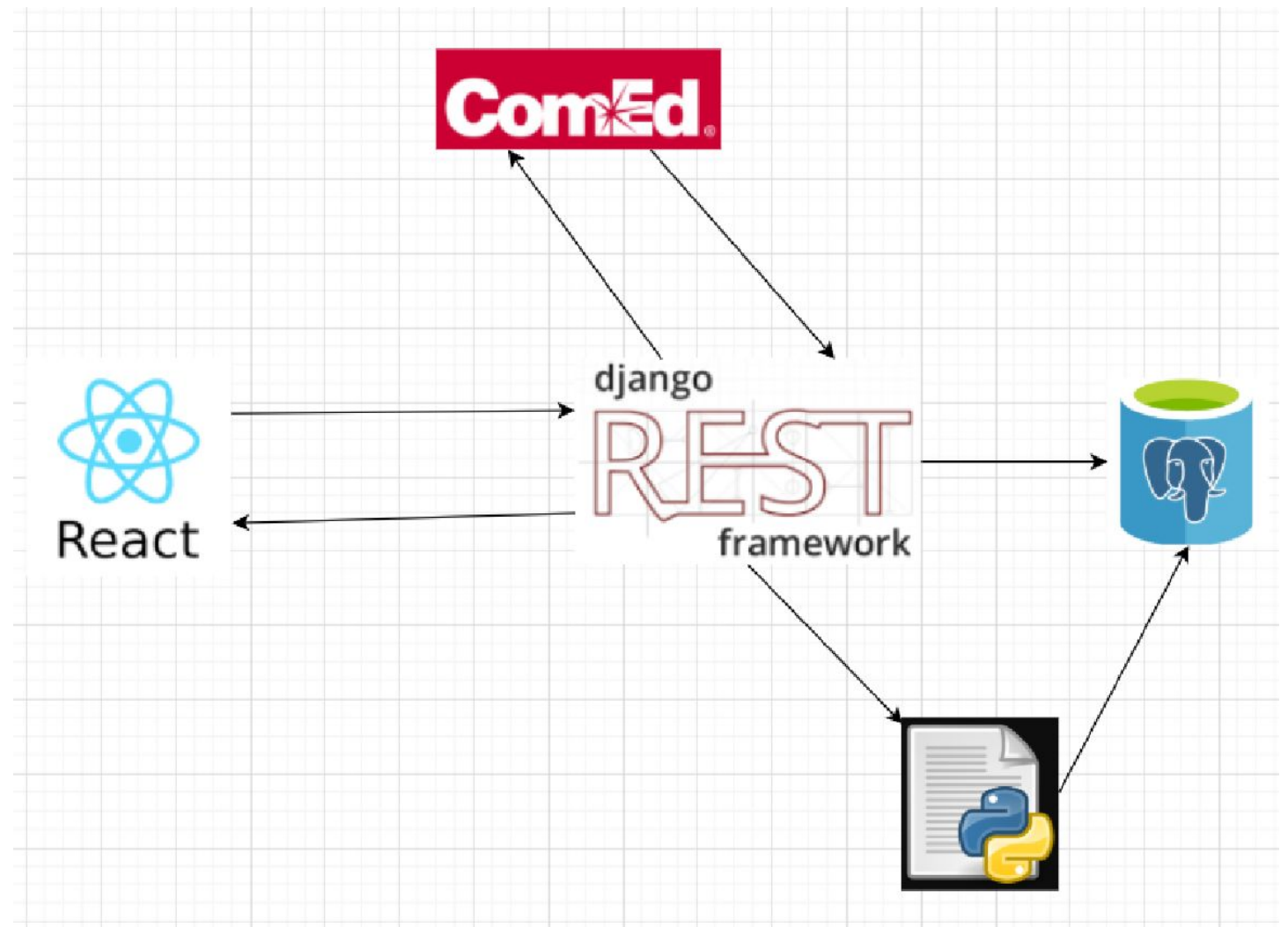
Body Cookies Headers (7) Test Results

Pretty Raw Preview Visualize JSON

```
1 {
2   "millisUTC": "1589805900000",
3   "price": "1.9"
4 },
5 {
6   "millisUTC": "1589805600000",
7   "price": "2.1"
8 },
9 {
10  "millisUTC": "1589805300000",
11  "price": "1.7"
12 },
13 {
14  "millisUTC": "1589805000000",
15  "price": "1.7"
16 },
17 {
18  "millisUTC": "1589804700000",
19  "price": "1.7"
20 },
21 {
22  "millisUTC": "1589804400000",
23  "price": "1.5"
24 },
25 {
26  "millisUTC": "1589804100000",
27  "price": "1.4"
28 },
29 {
30  "millisUTC": "1589803800000",
31  "price": "1.5"
32 },
33 {
34  "millisUTC": "1589803500000",
35  "price": "1.6"
36 },
37 }
```



# SOFTWARE INFRASTRUCTURE



# MTV FRAMEWORK

- Model-Template-View
  - Model(Data Access Logic)
  - View(Business Logic)
  - Template(Presentation Logic) -> React
  - Controller -> Django itself

Price Strategy From Yesterday

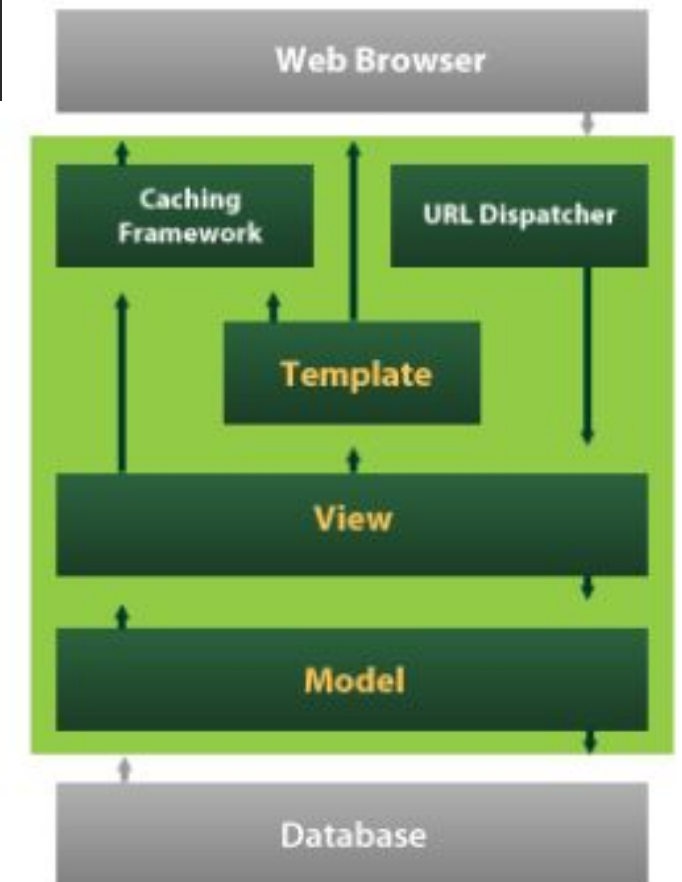
Date	Time	Overall Reward
17 May, 2020	03:00 UTC+8	140.791
16 May, 2020	03:00 UTC+8	82.508
15 May, 2020	03:00 UTC+8	91.612
14 May, 2020	03:00 UTC+8	112.463
13 May, 2020	03:00 UTC+8	97.742

```
class TableData(models.Model): # date
    dates = models.CharField(max_length=20)
    reward = models.FloatField()

    def __str__(self):
        return self.dates

class PriceData(models.Model):
    whole_price = models.FloatField()
    hours = models.CharField(max_length=10)
    date_id = models.IntegerField()
    #foreign key -> talbeData primary
```

# django



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Date	Time	Overall Reward
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# CONCLUSION

- Problem solving oriented on data science related issues
- Make use of data available to brainstorm derive other further business insight
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