Mitigating Risk in Green Cloud Computing

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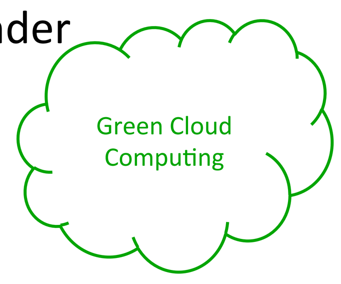
Background

- Cloud computing provides flexibility to cloud providers in allocating computation to data centers.
- However, the cost of electricity required for running these data centers is very high.
- About one third of this electricity is spent only on the cooling mechanism.
- Therefore, cloud providers are under financial pressure to become "Green".

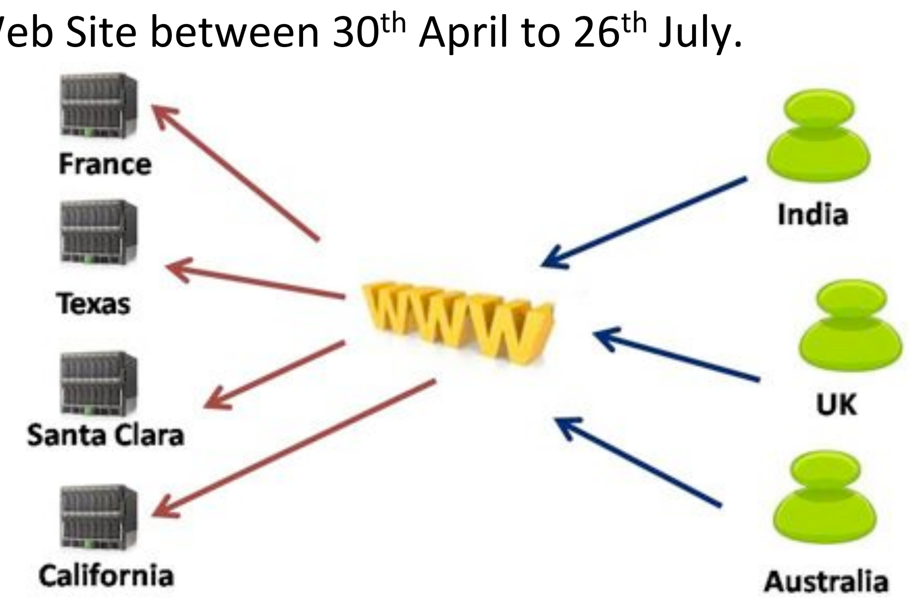


Objective

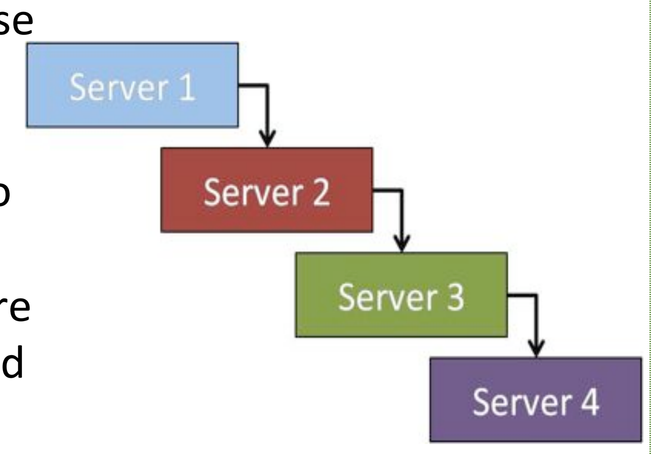
- How can a cloud provider become green by
  1. Saving energy and using environmentally friendly energy resources
  2. While simultaneously reducing the risk associated in shifting the responsibility to far-flung data centers.

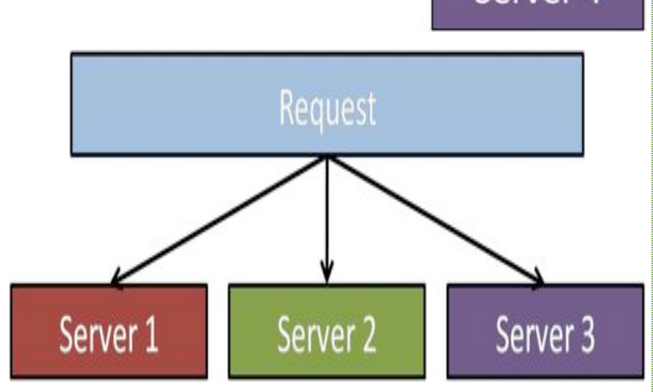
Approach

- Considered the requests made to the 1998 World Cup Web Site between 30th April to 26th July.



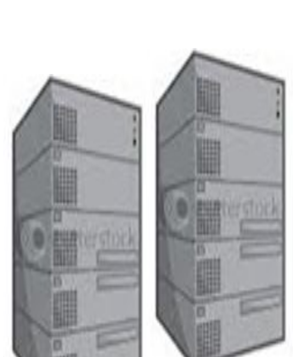
- From the access logs analyzed the server response size.
- Calculated the data center power consumption for two different models.
  - Waterfall model where the request is assigned to the servers in a sequential manner.
  - Evenly Distributed model where the request is distributed among the servers.



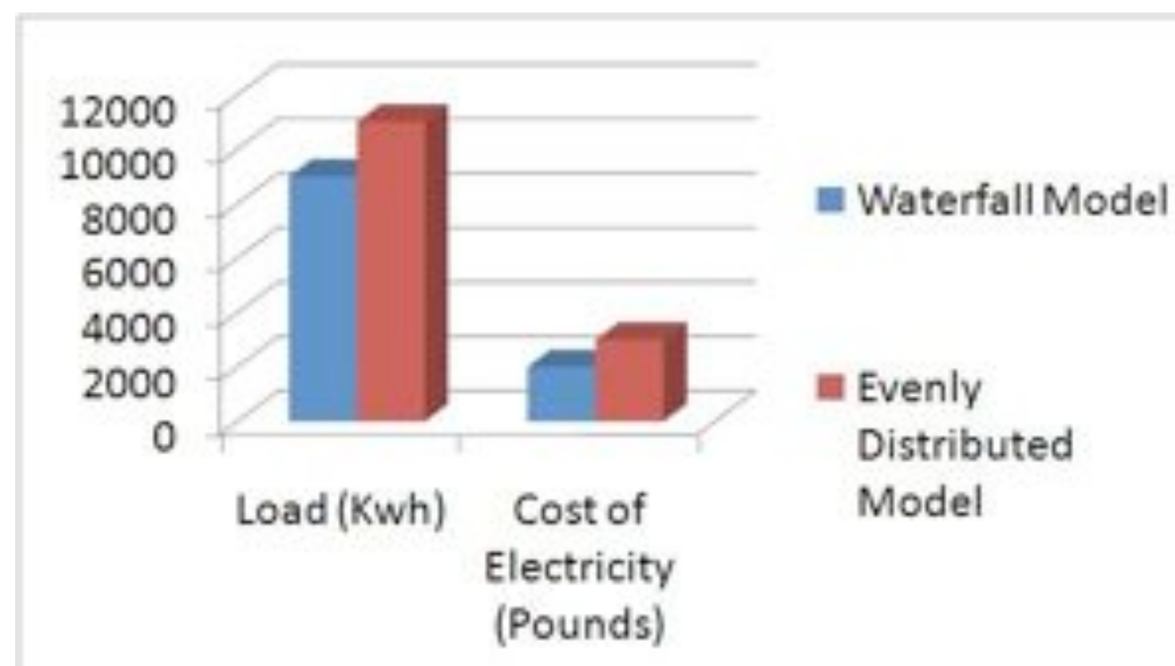


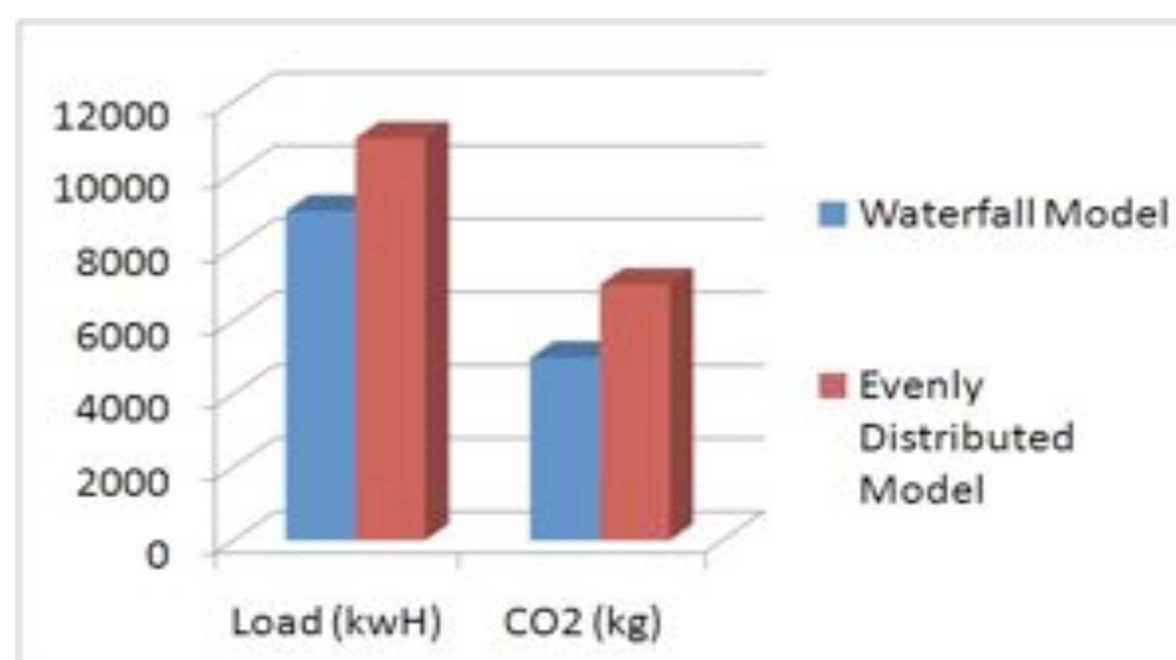
Findings

- From Server IBM system x3650 M2 or HP Prolian DL3xx Series:
  - Power when server is 100% utilized is 300 W.
  - Power when server is idle is 100 W/
- PUE = Total Power load of DC/IT equipment power load
- By analyzing the access log file from World Cup website , found the maximum size a server can respond at a time.
- Calculated the total size of server responses at a particular time stamp.
- In Waterfall Model on the basis of maximum size, allocated load to servers in a sequential manner.
- In Evenly Distributed Model, distributed the load among all servers.
- % Utilization = (100 * max size)/total size
- Power = idle power + (full power-idle power)* %utilization
- Multiplied it with PUE to obtain the total data center power load.



- Calculated the total load on data centers with waterfall and evenly distributed model at that particular time.
- Cost = Total DC power load * price of electricity / KwH
- CO2 = Total DC power load * 1 KwH Carbon yield.

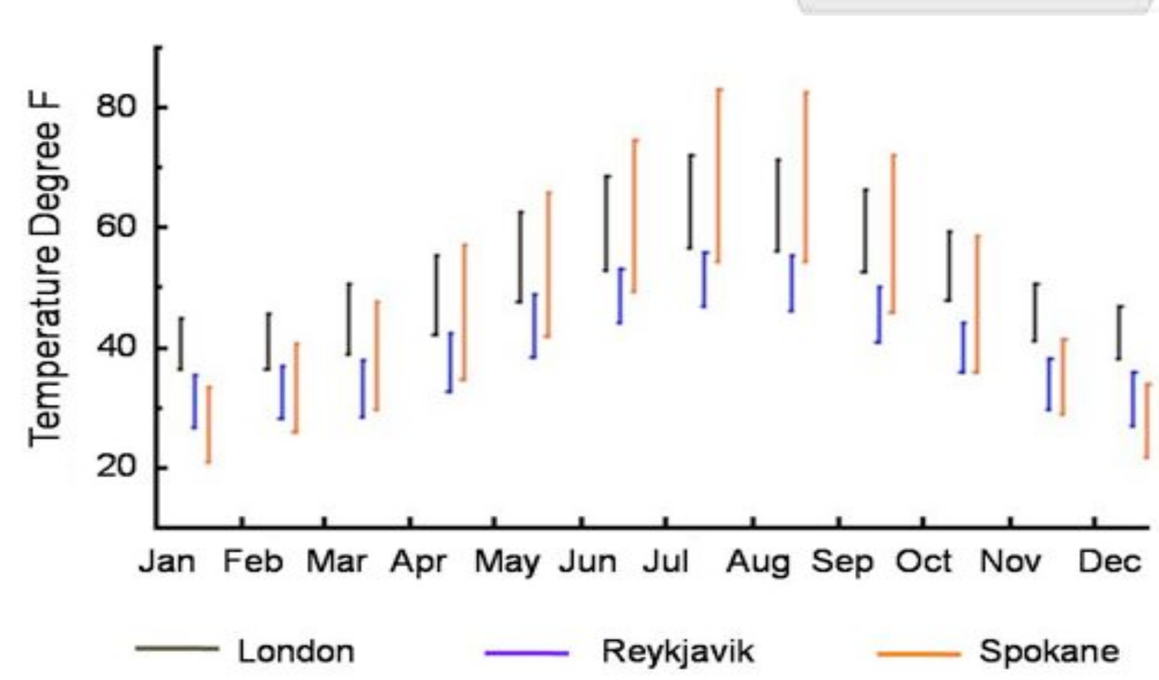




- Result:
  - Less load and lower cost of electricity in DC with Waterfall Model.
  - Less load and lower kgCO2 emission in DC with Waterfall Model.

The cost of computation at a given location is not uniform across time and space:

- Seasonal variations in temperature favor certain locations on month long timescale.
  - Iceland lows prevail during months of March and October.
  - Spokane lows prevail from November to February.



- Daily variations in temperature, coupled with time zone differences points to adaption between data centers on different continents.

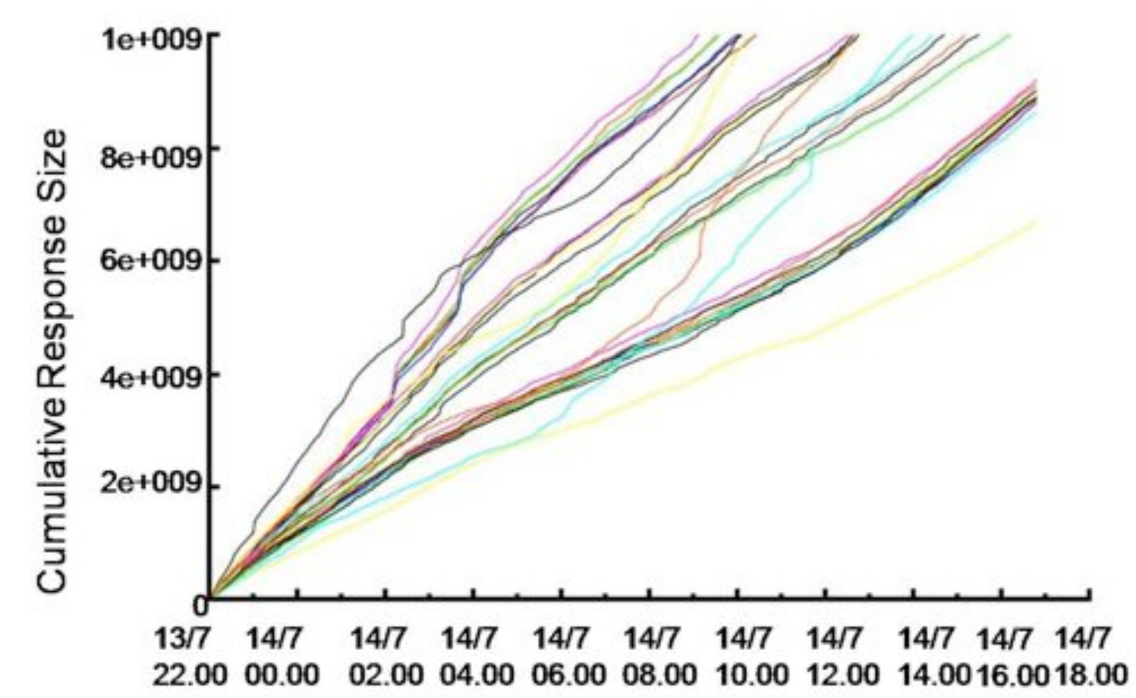
- Spot electricity markets introduce hourly electricity price variation at different location.
- Unique factors of country:
  - Iceland offers lower cost services in environment with low ambient temperature.

Complications

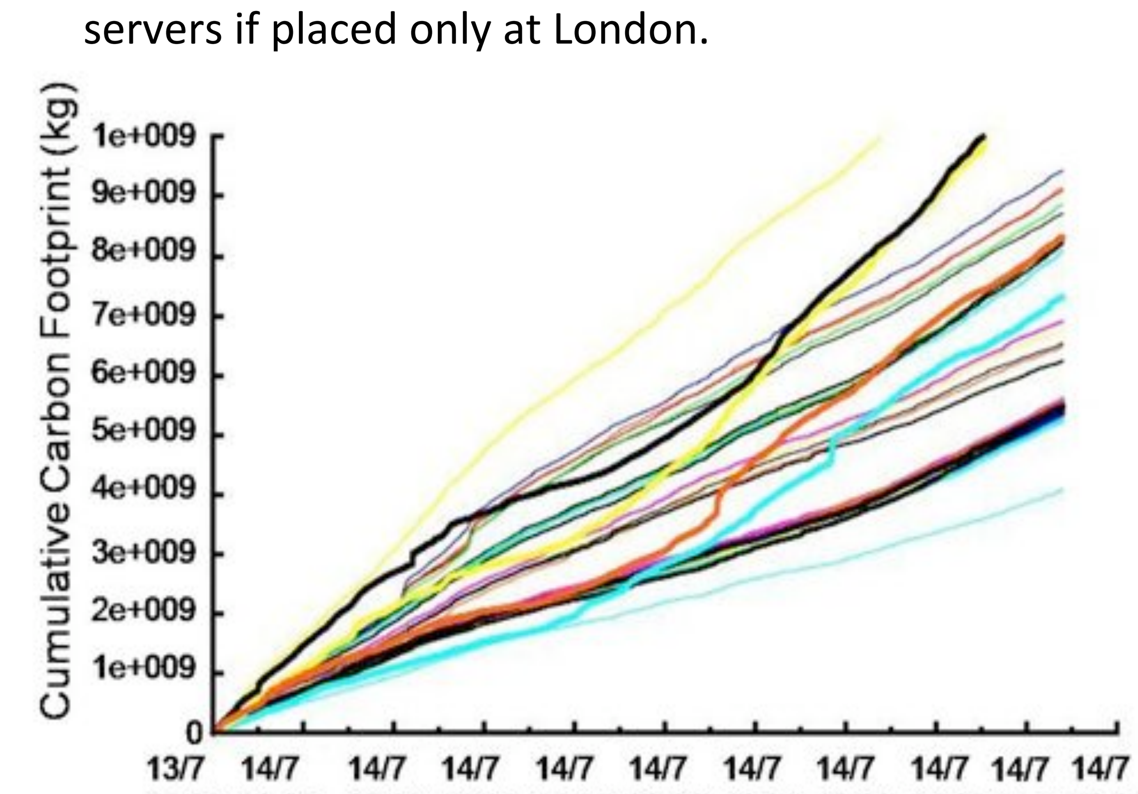
- Some computing jobs operate over large quantities of data and consume network capacity when they migrate.
- Providers may wish to favor a particular energy source over others for reasons external to our model.
- Countries roll out energy sources in differing proportions (like wind, hydro or geothermal power).

Possible Method

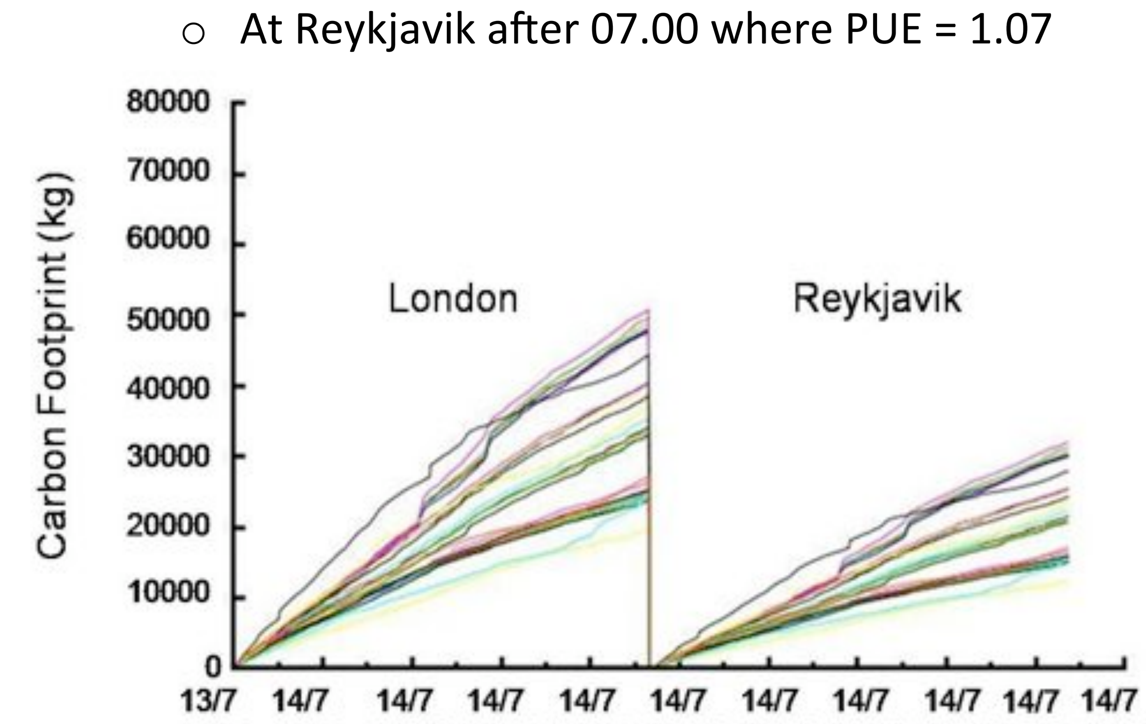
- Cumulative response size of web servers on Day 80.



- Cumulative kgCO2 produced by the work load on web servers if placed only at London.



- Cumulative kgCO2 produce by the work load on the web servers
  - At London before 07.00 where PUE = 1.7
  - At Reykjavik after 07.00 where PUE = 1.07



Future Work

Exploring these and other related issues:

- **Factoring in the carbon and monetary cost of moving data.**
- Modeling the improvements that energy aware cloud computing offers over an energy obvious distributed system.
- Reducing overall cost and using the greenest energy available.