Total Cost of Ownership in High Performance Computing

HPC- Data-Center TCO model

SoSe 14

Dozenten: Prof. dr. Thomas Ludwig, Dr. Manuel Dolz

Vortragender: Rickmer Weichenthal (rickmerweichenthal@gmail.com)

University of Hamburg

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1. Introduction to Modeling Costs

Contents

1.1 Modeling Costs

The TCO of a datacenter:

- At the top level: Capital expenses and Operational expenses

➔ Capex: Investments made upfront and depreciated over time
e.g.: construction costs of a datacenter, purchase costs for a server

➔ Opex: Recurring costs for running the equipment
e.g.: electricity, repairs & maintenance, human resources

1.1 Modeling Costs

At the top level

TCO= datacenter depreciation + datacenter Opex
+ server depreciation + server Opex

1.2 Capital Costs

Basically : Datacenter construction costs

- depending on: design, size, location, speed of construction
- small and very large datacenters are more expensive
- adding reliability and redundancy increases the costs

1.2 Capital Costs

- Expressed in dollars per watt → dollars / critical watt

→ makes sense for large datacenters

→ large datacenters cost approx. $12-15/W

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1.2 Capital Costs

Datacenter primary components:

- Power
- Cooling
- Space

➔ Normally 80% of construction costs are for power and cooling

➔ 20% are for building and site construction

1.2. Capital Costs Example

1.3 Operational Costs

Opex: Recurring costs for running the equipment
e.g.: electricity, repairs & maintenance, human resources

Depend on:

- operational standard (e.g. security guards, testing of generators)
- the size of the datacenter (larger are cheaper)
- geographic location
- design and age of the datacenter

1.3 Operational Costs

- monthly charge per watt
- Typical operational costs in the US range from 0.02$/w to 0.08$/w per month (excluding actual electricity costs)
- Operational cost for servers
  → hardware maintenance / repairs, electricity
- per - machine annual costs
- quantification of administration costs
  → mostly financed by vendors
- less administration for large – scale applications

3. TCO Models

3.1 Data Center Cost Model: Space, Power and Cooling

Key Drivers:

- “power, ping and pipe“
- space for building and equipment
- operational expenditures

- TCO: $Cost_{(total)} = Cost_{(space)} + Cost_{(power\ hardware)} + Cost_{(cooling)} + Cost_{(operation)}$

3.1.1 The Data Center Space

Real estate value consists of two parameters:

- the Net Operating Income per month (NOI)
  → difference between gross income and operation costs
- the Capitalization Rate (cap rate)
  → current valuation to expected return
  → between 9% and 13%
- real estate value: $Price_{(real\ estate)} = NOI/cap\ rate$
- Extended equasion:

  $Cost_{(space)}=((NOI/m^2)(A_{(data\ center)})(\%Occupancy)) / cap\ rate$

3.1.1 The Data Center Space: Example

- 100.000m^2 property
- 60.000m^2 data center
  → 50% occupied
- NOI: 50$/m^2
- ap rate: 10%

Estimated real estate value:

$Cost_{(real\ estate)} = ((50\$/m^2)(60.000m^2)(0{,}50))/0{,}10$

→ $Cost_{(real\ estate)}$ = 15 Mio $ (or 150$ per m^2)

3.1.1 The Data Center Space Second Example

Alternative Example to estimate leasing prices:

NOI/m^2=((Price(real estate))(Cap Rate))/
((%Occupancy)(A(data center)))

→ ((30.000.000$)(0,09))/((0,50)(60.000m^2)) = 90$/m^2

- To break even at 50% occupancy the operating income needs to be 90$/m^2

3.1.2 Cost of Power Delivery

Beside electricity costs:

- conditioning, battery back up, one site power generation, redundancy (delivery + generation)

Burdened Cost of Power Delivery:

$$Cost_{(power)} = U_{(Sgrid)} P_{(consumed\ hardware)} + K_1 U_{(Sgrid)} P_{(consumed\ hardware)}$$

→ K_1 is the power burdening factor

→ measure of increased costs (amortization and maintenance)

3.1.2 Cost of Power Delivery

$K_1 = J_1 \, U_{(S, A\&M\ power)} / U_{(Sgrid)}$

J_1 = maximum capacity (watts)/ utilized capacity

$\rightarrow P_{(rated)}/P_{(consumed\ hardware)}$

Combining the equasions:

$Cost_{(power)} = U_{(Sgrid)} \, P_{(consumed\ hardware)} + U_{(S, A\&M\ power)} \, P_{(rated)}$

3.1.2 Cost of Power Delivery Example

$U_{(S, A\&M\ power)} = U_{(Sgrid)} = 0{,}072\$/W$ per month

10 MW data center

And the data center is 75% utilized:

$\rightarrow J_1 = P_{(rated)} / P_{(consumed\ hardware)} = 10/7{,}5 = 1{,}33$

$\rightarrow K_1 = J_1\ U_{(S, A\&M\ power)} / U_{(Sgrid)} = 1{,}33$

$\rightarrow Cost_{(power)} = (1+K_1) U_{(Sgrid)}\ P_{(consumed\ hardware)}$

$= (2{,}33)(0{,}072\$/W)(7{,}5MW) = 1.260.000\$/month$

3.1.3 Cost of Cooling Ressources

Equivalent to Cost of Power Delivery:

$$Cost(Cooling) = U_{(Sgrid)}\, L_1 P_{(consumed\ hardware)} + U_{(S,\ A\&M\ cooling)}\, J_1 L_1 P_{(consumed\ hardware)}$$

3.2 Overall Model

$$Cost_{(space,power,cooling)} = (((\$/m^2)(A_{(data\ center)}))((\%Occupancy)) + (1+K_1+L_1+K_2\ L_1)U_{(Sgrid)}P_{(consumed\ hardware)}$$

4. Personell Costs

Personell Costs:

- M1= average numer of IT personell per rack
  M2=average numer of facilities personell per rack
  M3=average numer of administrative personell per rack
  S(avg)= Average salary of data center personell

Cost(personell per rack)= (M1+M2+M3)S(avg)=M(total)S(avg)

5.Conclusion

Modelling is a complex process wich needs a lot of time:

- It is easy to do mistakes
- You have to check your results several times
- But it is worth it
- Without modelling a lot of money would be wasted