A Model for Forecasting Data Centre Infrastructure Costs

CHEP 2015 @ Okinawa
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Introduction

- Context
  - Large computing resource requests to come
    - LHC, Astroparticles...
  - Tight funding situation

- Need of rationalization
  - What of data centre infrastructure?

- Recurrent kind of questions (as a site)
  - how much does and will an experiment computing cost me?
Aim of this talk

- How to estimate hosting cost in terms of infrastructure?
  - Hardware + Power
- The trends
  - Resource cost
  - Power consumption
- Model yearly resource investment
- Quantify and give estimates for the future
  - Assuming today's technos trends
  - No major (r)evolution in the next years
- Results for CC-IN2P3
Hardware
CPU and DAS costs

- Evolution of unitary cost with time
  - including rack, switch
  - €/HS06 or €/TB

![CPU cost](chart1)

![Disk cost](chart2)

- €/HS06
- €/TB

= Data

= Fit
What to do with that?

- One thing to consider
  - Hardware has a life time, you need to renew it
  - Makes things complicated, let's try to make it simple

\[
\text{Investment (t)} = \text{Capacity (t)} \times \text{Modeled Cost (t)}
\]

- Hardware Cost
  - Related to procurement cost, but
  - \textit{yearly} basis
  - \textit{includes renewal}
Modeled cost

This is the modeled cost
See backup for model formula

NB:
- tape cost not cheaper (HPSS)
- but price drops faster than disk
Power
Price & consumption
- Power price evolution hard to foresee
- Should increase by 5-10 % / year
Power consumption per service

- Measurements on PDUs
- Grouping by service
- Estimate of power consumption evolution with time
  - Per service (CPU, Disk, Tape, Other)
  - Including PUE
    - ⇔ hardware consumption + cooling
Unitary Power Consumption

Unitary consumption = Resource consumption ÷ Capacity

CPU power consumption per HS

-21.6 %/year

Disk power consumption per TB

-15.4 %/year
And... finally... the cost?
Final cost estimates

- So now the ingredients to answer the question:

\[
\text{Investment (t)} = \text{Capacity (t)} \times \text{Cost (t)}
\]

- Experiment requirements or pledges
- Hardware Modeled Cost + Power Cost
Example 1: LHC

Assuming 20% growth CPU
15% growth Disk
15% growth Tape
(see WLCG computing model update)
Example 1: LHC

Will we arrive at a point where power costs more than hardware?
Example 1: LHC

LHC: hardware cost
- CPU hardware cost
- Disk hardware cost
- Tape hardware cost
- Sum

LHC: power cost
- CPU power cost
- Disk power cost
- Tape power cost
- Sum

LHC: total cost (@ CCIN2P3)
- CPU cost
- Disk cost
- Tape cost
- Sum

Year
- 2013
- 2014
- 2015
- 2016
- 2017
- 2018
- 2019
- 2020
- 2021
- 2022
- 2023
- 2024
- 2025

€ / year
- 0
- 500k
- 1000k
- 1500k
- 2000k
Example 2: LSST

**LSST: total cost (@ CCIN2P3)**

- **CPU cost**
- **Disk cost**
- **Tape cost**
- **Sum**

**€ / year**

- 1000k
- 800k
- 600k
- 400k
- 200k
- 0k

**Year**

- 2014
- 2015
- 2016
- 2017
- 2018
- 2019
- 2020
- 2021
- 2022
- 2023
- 2024
- 2025
- 2026
- 2027
- 2028
- 2029
- 2030
- 2031
Example 3

- Assuming flat budget
- What growth should we expect?

<table>
<thead>
<tr>
<th></th>
<th>CPU</th>
<th>Disk</th>
<th>Tape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost model @ ccin2p3</td>
<td>25 %</td>
<td>18 %</td>
<td>38 %</td>
</tr>
<tr>
<td>WLCG computing model update</td>
<td>20 %</td>
<td>15 %</td>
<td>15 %</td>
</tr>
</tbody>
</table>

This is for CC-IN2P3
May change from site-to-site
- power price evolution
- tape storage system cost

Disagreement on
Tape storage potential growth
Summary and remarks

- A model that permits several things
  - Understand hardware and power costs of a data centre
  - Estimate funding needed for the future experiments
  - Tell me how much you need, I'll tell you how much it will cost

- Caveats to remember
  - Model smoothes things
    - Beware of year-to-year fluctuations in real life
  - Does not allow for major technology (r)evolutions
有難うございました
Tape cartridge cost

€ / TB

-27.5 %/year

year

Cartridge cost

HPSS

T10K tapes
Modeled cost

- **Hypothesis:**
  - Constant investment over time
  - Resource cost drops exponentially by « r % » per year (-CAGR)

\[
p^*(t) = \frac{r}{f} \times \frac{p(t)}{1-(1-r)^\tau}
\]

- \( p^* \): the modeled unitary cost
- \( p \): the actual unitary cost at procurement time
- \( f \): fraction of the investment dedicated to pure resources
- \( \tau \): hardware warranty time (years)
- \( r \): unitary cost decrease rate (eg 20%)
The trends

\[ C(t) = C_0 e^{-\alpha t} \]

- IT evolutions in exponential profile
- Resource cost decrease by X % per year (CAGR)