COST EFFICIENCY VS ENERGY EFFICIENCY

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TOPIC

- Cost Efficiency vs Energy Efficiency
  - How much money do we have to pay to acquire an HPC platform and to maintain it
  - in consideration of energy efficiency

OUTLINE

1. Introduction
2. HPC Platform
    1. What is it
    2. Why do we need such platforms?
3. Total Cost of Ownership
    1. TCO
    2. Lowering the cost
    3. Power Management
    4. Cooling
    5. Example: Google's Data Center
    6. Brainware
4. Conclusion

HPC PLATFORM

- High Performance Computing
- also called supercomputing
- „the solution of very difficult computing intensive problems in a reasonable time with the help of the fastest computers available“ [1]
- petaflops
- mostly used in scientific areas

HPC PLATFORM

- simulations
- benefits society and industry
- -> mistakes found during simulation are less costly and tragic

TOTAL COST OF OWNERSHIP

- building and maintaining an datacenter is expensive
- -> engineers need to focus on cost efficiency
- Total Cost of Ownership (TCO):
  - the money that is spend during a lifetime of a HPC platform

TOTAL COST OF OWNERSHIP

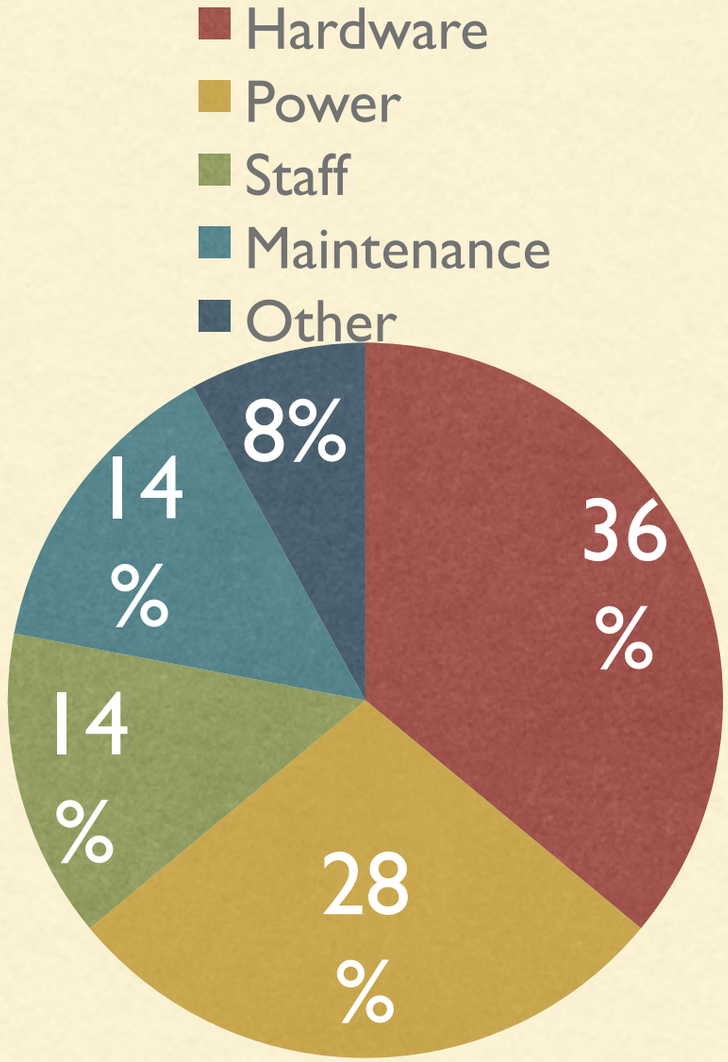
- Investment costs (to acquire an HPC Platform)
  - hardware (servers, storage, cooling systems, cabling, network, …)
  - software
  - datacenter construction
- Operational costs
  - Energy efficiency
  - Personnel („brainware“ pays off, more to it later)
  - Maintenance

TOTAL COST OF OWNERSHIP

- higher computing performance -> higher energy consumption
- energy costs have become a contributor to TCO
- Green500 list : reflects computing efficiency (not raw computing power)

TOTAL COST OF OWNERSHIP

- Investments worldwide:
  - 2011: $ 27 billion
  - 2012: $ 29 billion
  - 2017: $ 40 billion



TOTAL COST OF OWNERSHIP

- Tianhe-2:
  - #1 on Top500 and #49 on Green500
  - investment costs: $ 390 million
  - 24 MW (with cooling) -> $ 20 million/year
  - focused on hardware, but not on software

LOWERING THE COSTS

- better planning of the whole project
  - what kind of software do we need
  - is the supercomputer too powerful for the problem/ simulation it is designed for?
  - lowering the power consumption -> lowers costs

POWER MANAGEMENT

- Local and efficient energy sources
  - solar, wind or hydroelectric energy as a viable power generation
- Better cooling
  - other, new cooling systems
  - cooling servers at other temperatures then 20°C

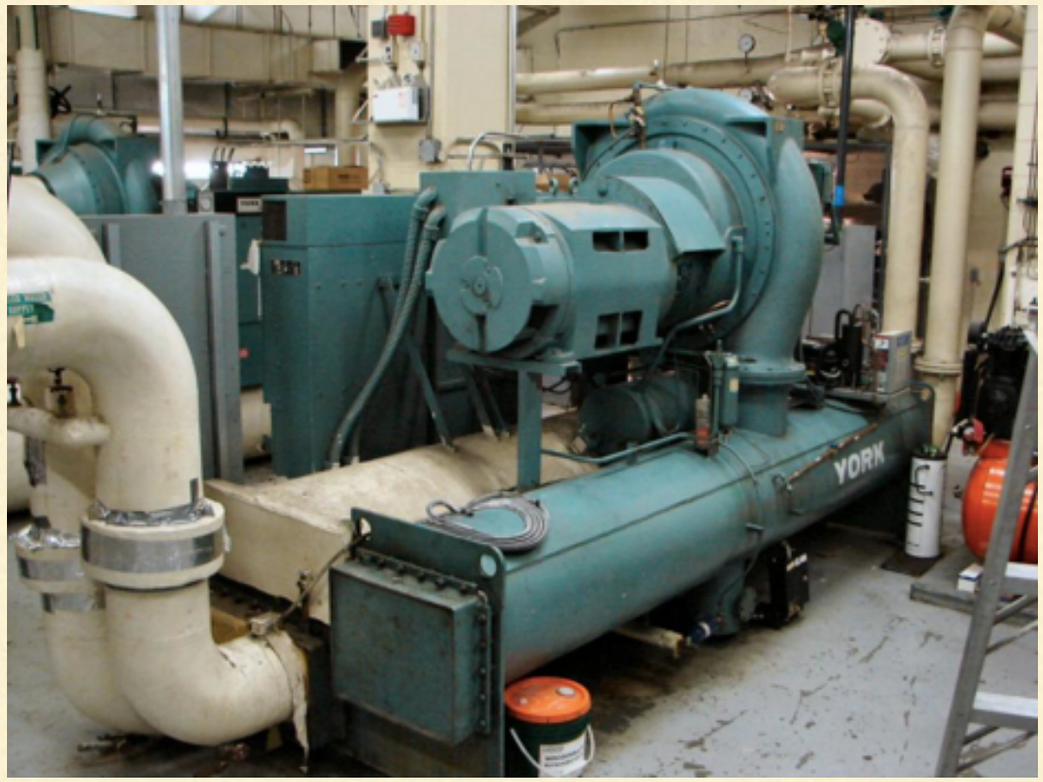
POWER MANAGEMENT

- Power Usage Effectiveness (PUE):
  - measures how efficiently a data center uses energy
  - ratio of total amount of energy used by the data center to the energy delivered to computing equipment.
  - PUE of 1.0 is ideal

$$PUE = \frac{\text{Total Facility Energy}}{\text{IT Equipment Energy}}$$

COOLING

- cooling takes much energy
- Traditional Cooling: chillers
  - cold water or liquid coolant exchange heat with the hot air
  - the hot liquid has to be cooled down to be reused -> chillers
  - removes heath via a vapor-compression



COOLING

- better way: cooling towers
  - warm water from data center flows down a tower
  - cools down mainly through evaporation
  - cheaper than chillers (free cooling)
  - in colder climates (but not too cold)

EXAMPLE: GOOGLE'S DATA CENTER

- first investment 2011: $200 million
  next investment 2012: $150 million
- use 50% less energy than average data centers
- cool their servers at 27°C
- cooling with cooling towers (or seawater)
- PUE of 1,12 across all data centers

Google data center in Hamina, Finland

BRAINWARE

- „Brainware"
  - HPC performance experts
  - analyze HPC efficiency (of hardware)
  - cost less than the hardware they rendered unnecessary
  - Important aspect of energy efficiency

BRAINWARE

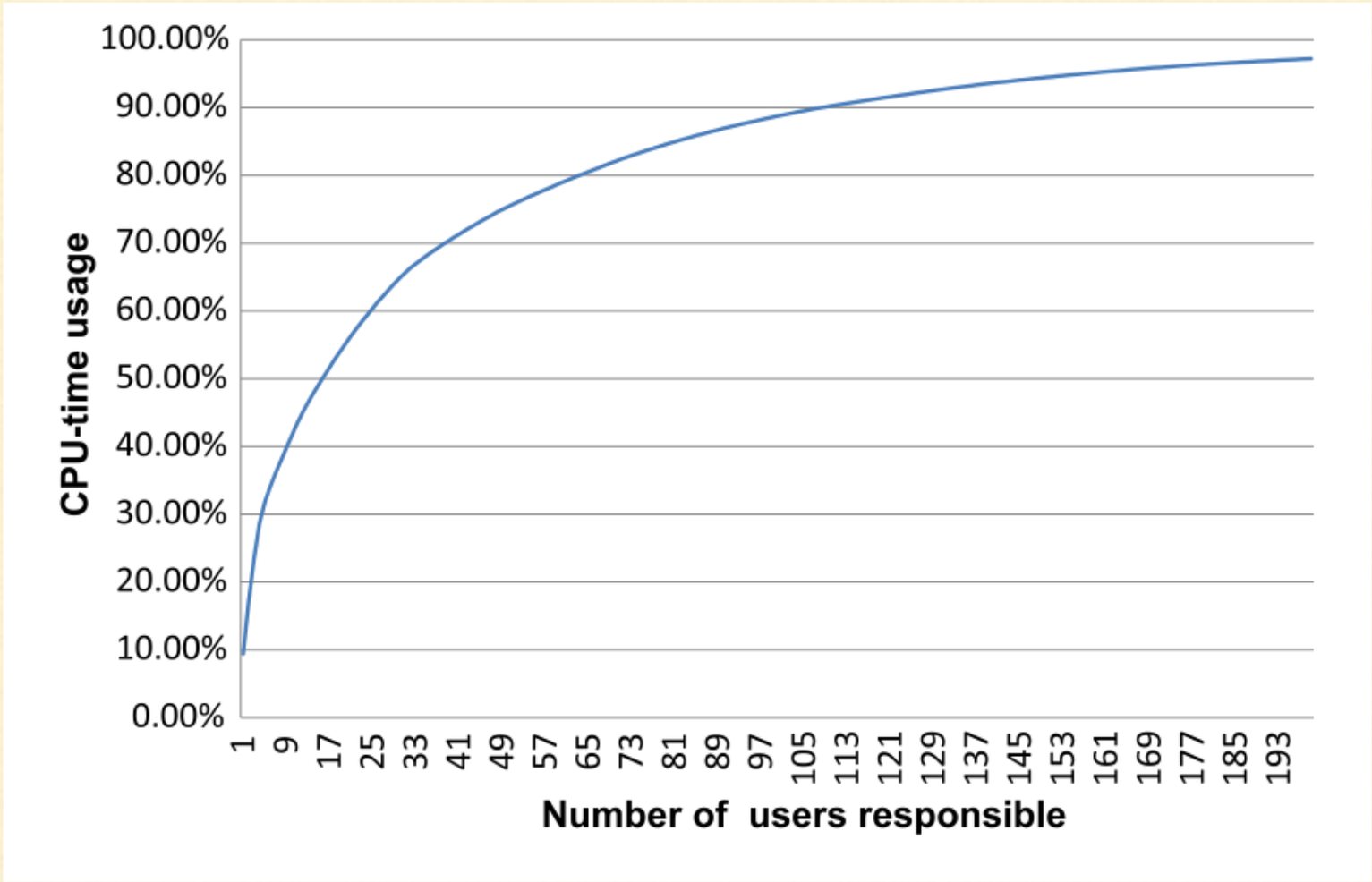
- Assumptions:
  - 7,5 € Mio for Infrastructure
  - Hardware 2 Mio €
- 4 years maintenance, then new hardware
- Power consumption: 850 KW
- ISV software provided by users

	COST/YEAR	PERCENTAGE
BUILDING	300.000 €	5,46 %
INVESTMENT	2.000.000 €	36,14 %
HARDWARE MAINTENANCE	800.000 €	14,46 %
POWER	1.563.660 €	28,26 %
LINUX	0 €	0,00 %
BATCH SYSTEM	100.000 €	1,81 %
ISV SOFTWARE	0 €	0,00 %
HPC SOFTWARE	50.000 €	0,90 %
STAFF (12 FTE)	720.000 €	13,01 %
TOTAL SUM	5.533.660 €	100 %

BRAINWARE

- It takes 2 months to tune one project
- An expert can handle 5 projects per year
- HPC experts can improve the performance of projects by 5,10 or 20 %
- HPC performence expert can take care of 10 projects at a timeti
- First take care of the „hot spots“ (top projects in order of CPU usage)

BRAINWARE



„Brainware for Green HPC“ ; Christian Bischof, Dieter an Mey, Christian Iwainsky

BRAINWARE

- Example:
  - 1,5 FTE
  - take care of 15 projects
  - 50 % of CPU usage
  - 10% performance improvement
  - => 0,1 * 0,5 * 5,5 Mio € - 1,5 * 60000 € = 185000 € Savings

BRAINWARE

- Example:
  - 3 FTE
  - 30 projects
  - 60 % CPU usage
  - 0,2 * 0,6 * 5,5 Mio € - 3 * 60000 € = 480000 € Savings
- Brainware pays off

CONCLUSION

- higher computation power -> higher energy consumption -> higher costs
- good planning needed
- different methods to lower the TCO
  - but: making an HPC more energy efficient, makes ist also more cost-efficient

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