

Topic : Techniques for Reducing Power Consumption in Data Centers
15 minute video, 5 minute/section approx.

Introduction

Briefly introduce the chosen problem-specific topic

What is a data center : Building, space within a building or multiple buildings used to store computer parts and systems, which include but not limited to telecommunications and storage systems, as well as process and communicate data from information services, like video streaming or social media

- Some of the bigger data centers can use as much electricity as a small town
- Amount of power can range from a few kW (kilowatts) for a row of servers to several MW (megawatts) for larger data centers
- Requires high amounts of cooling power, due to the amount of computing power and systems within the data center

Statistic : 2022 - The estimated amount of electricity consumed by global data centers was 240 - 340 TWh (Terawatt-hour) or about 1 - 1.3% of global electricity demand, but does not include cryptocurrency mining

- Data centers can consume up to 1000 kWh per square meter, and about 1800 - 1900 kWh/year (According to cc-techgroup.com/data-center-energy-consumption/)

Explain the basic science and foundational concepts related to the problem

Around 80% of the world's energy is still being generated by using fossil fuels, so with the increase in power needs from data centers, it has led to environmental conflicts, such as CO2 emissions

- It was found that global data centers emit the same amount of CO2 as the aviation industry - about 915 million tonnes (According to cc-techgroup.com/data-center-energy-consumption/)

Power Usage Effectiveness - can measure how energy efficient a data center is by getting the ratio between the total amount of energy used by the data center to the energy being used by the computing equipment (ideal is 1.0)

- Cooling systems and servers are the two main reasons for high energy consumption in data centers
 - Cooling systems are rather inefficient and use around 70% of the total energy used in a data center, one reason is because they must process multiple services at once
- Per the US Department of Energy, the largest data centers with multiple systems requires over 100 MW of power, which can power approximately 80,000 households (According to cc-techgroup.com/data-center-energy-consumption/)

- Server racks are common equipment used in data centers that consume large amounts of energy to cool and maintain the computer systems they hold

Operating costs of data centers : In data centers that consume large amounts of power, the cost of electricity contributes to the highest expense of the total cost of ownership of the data center, which is over 10%

- Can consume over \$20 million in electricity costs in its lifetime
- Cooling the data center interiors below a certain temperature wastes money and energy
 - Cost of cooling contributes 35% - 45% of the total cost of ownership of the data center

Literature review

Present a summary of key research papers and sources

Discuss historical developments and important milestones relevant to the problem

Aisle systems

- Line up computer systems in a way where the hot air generated from computer systems is blown out of the workspace and the computer systems take in fresh cold air
- Helps reduce PUE points and decreases overall cost of running the data center
 - It could reduce the PUE in a data center from 1.85 to 1.55 with a financial pay back less than six months (According to <https://www.energyinst.org/?a=1406810>)
- When a data center divides the hot air from the cold, you can save about 25% in energy costs compared to data centers that don't incorporate aisle systems

Chilled storage

- Store water in a reservoir to be used for cooling the computer systems, effective in data centers with a large amount of computer systems that need to be cooled
- When the outdoors has a low enough temperature, cooling towers will cool a designated water tank into ice, then the ice will be used to cool the computer systems
 - When the ice melts slowly, the cold water will act as a cooling system
- Can help save money for electricity and become more reliable if more people were to use this system

Cable management

- Common practice when working with computer systems
- When there are cables lying around, it obstructs the flow of cooling air within the data center
- Find cables that cannot or are not being used and remove them to limit and reduce amount of stray cables lying around

Green data centers

- These data centers use newer and energy efficient technologies

- Low-power servers - more energy efficient, uses software to balance performance and energy consumed
- Free air cooling - uses external wind to cool computer systems instead of Computer Room Air Conditioner units (CRAC)
- Direct current data centers - uses solar panels to generate direct current energy and store the energy generated in a battery storage power station
 - Because computers run on direct current, there is no need to convert the power to AC, making a data center that solely runs on DC power 10% more efficient than data centers that do not incorporate this technology
- LEED - Leadership in Energy and Environmental Design, developed by the US Green Building Council
 - Can grant a data center either a silver, gold or platinum certification
 - Platinum being when the data center is built environmentally responsible and uses their resources efficiently
- National Data Center Energy Efficiency Information Program by Energy Star
 - Program that gives certification to buildings and appliances when they are energy efficient
 - For a data center to receive an Energy Star certification, it must be in the top 25% in energy performance

Current innovations

Highlight recent advancements and cutting-edge research addressing the problem

- Infineon - company working towards green and efficient energy (According to their website) and makes high-performance power semiconductors
 - It can improve computer system architecture, makes power supplies more efficient and decrease the amount of energy needed to cool computer systems
- Using the semiconductor can lead to :
 - Yearly energy savings of up to 10.5%
 - Potential yearly energy savings for a mid-sized data center of around 115 GWh and reducing the data centers' CO2 emissions by around 4,700 tons per year
- If this company's semiconductors are incorporated into multiple systems, around 48 TWh of energy can be saved, which compares to over 22 million tons of CO2 emissions
- By using newer technologies like Silicon Carbide (SiC) and Gallium Nitride (GaN), we can see an increase in power efficiency and lower cost
- By optimizing power supply unit, we can increase energy efficiency by a large scale of up to 97.5%
 - By using multiple semiconductor types and combining Infineon technologies, we can increase energy efficiency
 - Can reduce over 50% of power loss, compared to a non-optimized power supply unit

Discuss practical applications and future prospects

- Optimize the way the computer systems within a data center is being cooled
- Dynamic power optimization - develop applications that control the amount of power that a computer system is consuming based on the amount of work it needs to complete, this makes it so the system only consumes power when needed
- Remove obsolete technologies and replace them with recent energy and temperature efficient technologies
- Remove servers that are not in use but are still consuming power
- Improve ventilation within the data center
 - Placing the computer systems in arranged spots - can improve air flow, prevent hot air mixing with cold air - improves temperature efficiency
 - Air-side economizer - can bring in cold air from outside to inside the data center
- Liquid cooling - circulating coolants directly through systems in the data center or placing the components in a non-conductive liquid can help remove the heat they produce more effectively

Analysis and critical discussion

Provide an insightful analysis of the topic

Discuss challenges, benefits and potential future developments

Developments in... are essential for reducing the power consumption in data centers :

Energy efficient heat removal technologies

- Cooling systems and servers are the two main reasons for high energy consumption in data centers
- Cooling systems are rather inefficient and use around 70% of the total energy used in a data center, one reason is because they must process multiple services at once
- Aisle systems : Line up computer systems in a way where the hot air generated from computer systems is blown out of the workspace and the computer systems take in fresh cold air, when a data center divides the hot air from the cold, you can save about 25% in energy costs compared to data centers that don't incorporate aisle systems
- Chilled storage :
 - Store water in a reservoir to be used for cooling the computer systems, effective in data centers with a large amount of computer systems that need to be cooled
 - When the outdoors has a low enough temperature, cooling towers will cool a designated water tank into ice, then the ice will be used to cool the computer systems
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Computing and storage systems

- Cable management
 - Common practice when working with computer systems

- When there are cables lying around, it obstructs the flow of cooling air within the data center
- Find cables that cannot or are not being used and remove them to limit and reduce amount of stray cables lying around
- Semiconductor made with certain materials from Infineon
 - Yearly energy savings of up to 10.5%
 - Potential yearly energy savings for a mid-sized data center of around 115 GWh and reducing the data centers' CO2 emissions by around 4,700 tons per year
- Dynamic power optimization - develop applications that control the amount of power that a computer system is consuming based on the amount of work it needs to complete, this makes it so the system only consumes power when needed
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Green data centers

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Invest and work together with companies that are trying to have energy efficient data centers as well as make them sustainable

- Infineon, Energy Star, LEED

Conclusion

Summarize key points from the presentation

Reflect on the overall significance and impact of the topic

To conclude

- Data centers are buildings that play a role in our daily lives, like for telecommunications or video streaming and even social media

- But the main problem behind the data centers is that they consume too much energy to run
- Because of all the computer systems and the cooling for said computer systems
- We can monitor energy consumption and the efficiency of how the power is consumed with the Power Usage Effectiveness ratio
- Incorporate energy efficient cooling systems and techniques, aisle systems liquid cooling air side economizer dynamic power optimization
- Eco friendly energy generation with renewable sources
- But with the help of some companies and programs, we can slowly build towards greener and more eco friendly data centers in the future

References

July 19, 2024. *Data center*. https://en.wikipedia.org/wiki/Data_center

Data Centers: Making Green Energy Happen - Infineon Technologies.
<https://www.infineon.com/cms/en/about-infineon/energy-efficiency-technologies/data-centers/>

Data Centers Solutions.
https://xcelerator.siemens.com/global/en/industries/data-centers.html?gclid=CjwKCAjwko21BhAPEiwAwfaQCPOjaauomK66Rced7bA7Z5-0fmhCxcyoDuzArluLl8xpGtrYPHjIIxoCy7MQAvD_BwE&acz=1&gad_source=1

Energy-efficient data centres. <https://www.energyinst.org/?a=1406810>.

March 12, 2024. *Energy-Efficient Data Centers: Innovations in Cooling and Power Management*.
<https://medium.com/@codebykrishna/energy-efficient-data-centers-innovations-in-cooling-and-power-management-5ba073600102>

May 09, 2024. *Green data center*. https://en.wikipedia.org/wiki/Green_data_center

May 13, 2024. *How Much Energy Do Data Centers Really Use?*
<https://energyinnovation.org/2020/03/17/how-much-energy-do-data-centers-really-use/>

June 12, 2024. *Power usage effectiveness*.
https://en.wikipedia.org/wiki/Power_usage_effectiveness

Understanding Data Center Energy Consumption - C&C Technology Group.
<https://cc-techgroup.com/data-center-energy-consumption/>