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DESIGN A MATHEMATICAL MODEL FOR OPTIMIZING ENERGY CONSUMPTION FOR DATA CENTERS

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Abstract
As IT and cloud services platforms need more computing power and storage space, the need for hosting services in data centres grows. On these platforms, there is a higher need for electricity to power IT equipment and keep data centres cool. In recent years, it has become harder to make data centres as efficient as possible without putting the quality of their energy supply at risk. This is because there are more and more places that need to store data. Because of this, many different optimization algorithms that use machine learning to improve power efficiency have been made. This report tries to figure out and rate the different ways researchers use machine learning algorithms to optimise how much energy a data centre uses. It does this by looking at the main ongoing research done between and. This evaluation is meant to help scholars decide which methods to use based on good information. Machine learning is talked about in terms of how it can help improve the power efficiency of data centres. This study suggests that one possible next step is to use a bio-inspired optimization and neural network. This was done so that the parameters could be set.

1. Introduction

Many businesses need to store and process a lot of data in places called data centres, which are centralised places. Businesses of all kinds use these facilities to meet their needs. A "data centre" is a building where many servers and network infrastructure are kept. Servers collect data, which is then processed and kept up to date by network infrastructure. Users can access the data by connecting to servers in a data centre over a network.

There has been an amazing growth in the amount of knowledge and a rapid growth in the number of people. Data centres are an important part of the infrastructure that makes this kind of progress possible. Data centre technologies are now at the centre of a "information contest" between big IT companies that want to control the cloud computing market as it grows along with green computing ideas. When setting up data centres, it's not just about how fast they can process data. More and more people are worried about the huge amounts of power that data centres need to run.

the parts of data centres that use the most electricity as a whole. They account for most of the costs of running the business. As a result, reducing the energy used by servers and cooling systems has become the top priority for expanding green data centres.

Most of the time, the high cost of electricity in these areas prevents the building of data centres, which need a lot of power. The "carbon footprint" is also growing at an alarming rate, which only makes the damage to the environment worse. Both the academic world and the business world have raised concerns about how much energy data centres use.

Based on what has been said so far, we could say that most of a data center's energy use comes from high-performance computing, low-power servers, saving energy in computer rooms, and using renewable energy sources. The goal of this paper is to give a high-level look at the most important parts of a full framework for energy efficiency in data centres. The goal of these energy-saving ideas is to make data centres as efficient as possible while also reducing their impact on the environment in a way that changes based on what users want and other factors.

2. Related work

Huigui, et al. (2016) This article is about how to design, build, and run a data centre in a way that saves energy. The use of renewable energy sources, energy-saving technologies for server rooms, and high-performance computing are some of the things that are talked about. Here, we give a full list of suggestions for how to improve the performance of data centres while reducing their impact on the environment. Energy efficiency, saving money, and protecting the environment are just a few of the many things that these plans take into account. This paper also talks about new ways to make data centres use less energy.

G H S Kaushik,et al.(2019) Because it uses so much electricity, a data centre puts a lot of carbon dioxide into the air. The biggest and most difficult problem with cloud computing is how to make it green by using strategies that make the most of the energy that is available. It has less of an effect on the environment and costs less to run. Even though there is a lot of uncertainty about locally made renewable energies, we know how important it is for the human race to use green energy and warn against getting a lot of brown energy from one source. So, our algorithm that changes over time offers a realistic way to use renewable energy.

Ding et al.(2022) In this study, we suggest a data structure that is an improved version of a method that was used before. The goal is to change the fitness computation difficulty of the VM-placement problem from a quadratic function of the input size to a linear function. It is suggested that a different fitness function be added to this data structure as a way to improve the general algorithm's performance in terms of how long it takes to run. Experiments have shown that our technology can speed up GA computation by a factor of 11. This means that virtual machines can be placed more efficiently in large data centres with around 1500 physical processors to save energy.

Huda Ibrahim et al.(2018) The main point of this essay is to make an algorithm for dynamically scheduling tasks. To do this, a method based on Integer Linear Programming (ILP) is suggested to reduce the amount of power a cloud data centre needs to run. We suggest using an Adaptive Genetic Algorithm (GA) to find a near-optimal scheduling solution that uses the least amount of energy and takes into account the fact that the Cloud is always changing. This step was taken so that the above goals could be reached. As a way to make sure the proposed adaptive GA works, we ran a series of tests in a situation that mimics the infrastructure of the cloud to check its performance and quality.

Sahar et al.(2015) This study suggested using a genetic algorithm to divide tasks among virtual machines in an effective way. The resources are split up based on how much power each virtual machine uses and how many resources are available. The proposed method is better than both the first-fit decreasing (FFD) and the best-fit decreasing (BFD) algorithms in terms of being able to grow and using less energy.

3. Methodology

how much power computers and other electronic devices use, with a focus on how to use less power (especially in networks).

3.1 Servers and switches in data centres use a lot of electricity.

The computers and servers in a data centre use up most of the electricity in the building. The amount of energy a server computer needs is directly related to how long its central processing unit is running. Even when it's not being used, a server still uses about two-thirds of the power it would use at peak load just to keep its memory, discs, and I/O resources online and working.

$$P_s(l) = P_{fixed} + \frac{(P_{peak} - P_{fixed})}{2}(1 + l - e^{-\frac{l}{a}}),$$

The Distributed Volume File System (DVFS) and Distributed Power Management are the two most common ways to make servers use less energy (DPM). The main method adjusts the amount of CPU power (and, by extension, performance) based on how much work is being done at the moment. Since this DVFS optimization only affects the CPUs, the operating frequencies of the buses, memory, and discs will stay the same. Compared to the DVFS system, powering up (or shutting down) takes a lot more power. But the DPM method is much better because it can shut down servers while keeping all of their parts up and running. Another way to talk about frequency reductions is as follows:

$$P_s(l) = P_{fixed} + \frac{(P_{peak} - P_{fixed})}{2}(1 + l^3 - e^{-\frac{l^3}{a}}),$$

Figure 1 shows how much power a typical computer server needs.

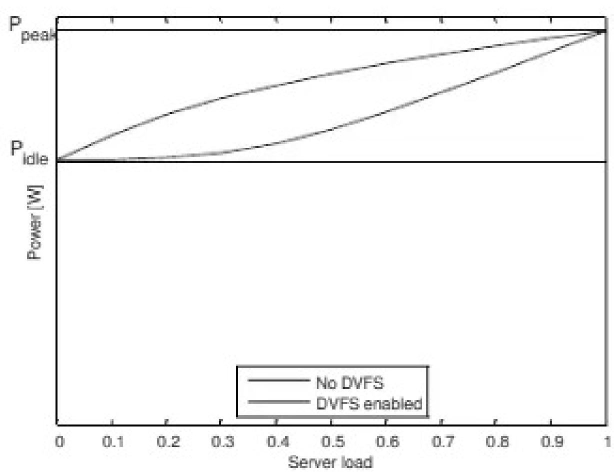

Fig. 1How much electricity do data centres need?

Users' requests can be sent to the right compute servers to be handled with the help of network switches. There are many things that affect how much energy a switch uses as a whole, but there are a few that stand out: The transmission rates of the ports, the number of ports, the cabling options, and the type of switch all matter. You can show these things with

$$P_{switch} = P_{chassis} + n_c * P_{linecard} + \sum_{r=1}^{R} n_p^r * P_p^r * u_p^r,$$

the following models:

Putting energy to good use

The electricity would go to the IT hardware that was processing the requests of the users. After that, this power would be divided between the computer and the network. Several studies have wrongly thought that the communication network was just an extra cost that was needed to get the jobs to the servers that do the work. We'll see, though, that communication is important for doing any task. The features of the communication network, such as its bandwidth capacity, transmission delay, delay jitter, buffering, loss ratio, and the performance of communication protocols, have a big impact on how well a task is done.

Optimization of data centre systems to get the most out of their efficiency

Using optimizations in areas like scheduling, load balancing, data replication, virtual machine placement, and networking, data centres can save energy.

Task schedulers often use a policy called "workload consolidation" to make it easier on the servers that do operational computing and to make it possible to put more servers to sleep. Because of this, the operational computing servers are the ones that get the most work. But the way networks are set up in most data centres requires different policies, so this kind of scheduling policy only really works for systems that can be thought of as a pool of compute servers that are all the same. Figure 2 shows the most common type of design for a data centre, which is a "fat tree." It could put all of the heavily used computing servers in a small number of racks and schedule them all at once. But this makes network traffic slow down at a rack or aggregation switch.

A typical rack can hold up to 48 servers, but it can only be connected to the aggregation network by two 10 GbE lines. The difference between the 48 GE of bandwidth coming in and the 20 GE of bandwidth going out is 2.4. In a data centre that uses cloud services that need it, it is important for the scheduler to find a balance between concentrating the workload and spreading out the network traffic.

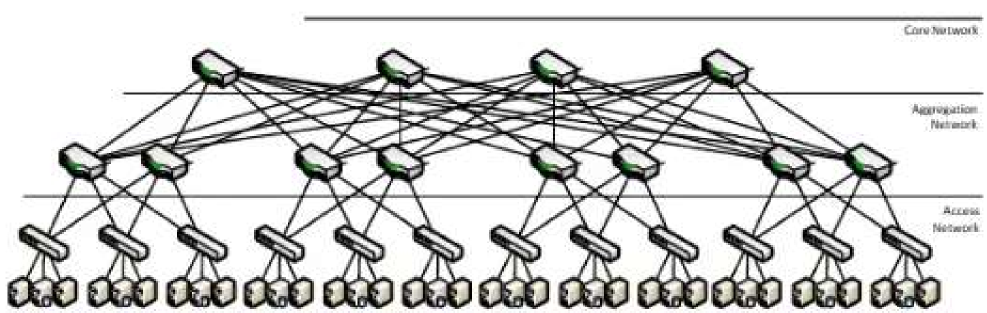

Fig. 2. A data center that has three levels

Any of the switches in the data centre could get backed up in either the uplink or the downlink direction, or in both. As the capacity of each ingress link gets bigger than that of each egress link, traffic builds up in the downlink direction.

the DENS method, which chooses the best computing resource for a job by taking into account the expected communication needs of the data center's parts and the current load level. The goal is to use less energy. By "communicational potential," we mean the end-to-end bandwidth that certain servers or groups of servers can use because of how the data centre is set up. The DENS method uses a hierarchical structure that fits with the most modern way that data centres are built. Traditional scheduling solutions, on the other hand, tend to treat datacenters as one big pool of servers that are all the same. But traditional ways of making schedules are still good choices.

$$M = \alpha \cdot f_s + \beta \cdot f_r + \gamma \cdot f_m$$

In this case, the important parts (servers, racks, and/or modules) are shown by weighted coefficients, where, and show how much each part affects how the measure works. We use weighted coefficients, where, and, to show how important each part is in relation to the others. The higher the value, the more likely it is that servers with full loads will be put in racks that are mostly empty.

4. Conclusion

The cost of energy use is a big part of how much it costs to run the data centres that house the computer equipment. In this chapter, we'll look at how communication and network awareness can reduce the amount of energy used by cloud computing, as well as how to put these changes into place.

Most of the current IT solutions to save energy and improve performance focus on computing, while communications-related tasks are either ignored or given less importance. In reality, though, what makes cloud computing systems work is communication. Some network factors that could affect the quality of task execution are bandwidth capacity, transmission delay, delay jitter, buffering, loss rate, and the performance of communication protocols.

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