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Survey on Energy Consuming for Database in Different Data Center

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Abstract - *The major issue in data base and data center operations is Energy management. The primary goal of traditional data base is performance, which means to run the query faster without taking energy cost into consideration. Data centers are consume large amounts of energy; one part of energy consuming is database. Database systems, being a major consumer of computing resources (thus energy) in modern current data centers and face the challenges to reduce the power. In this paper we are going to describe the energy consuming for database in different data center, also describe the different method used to evaluation of energy-efficiency solutions.*

1. INTRODUCTION

Database management systems (DBMSs) have largely ignored the task of managing the energy consumed during query processing. Both economical and environmental factors now require that DBMSs pay close attention to energy consumption.

It is clear that with these growing energy cost and energy-inefficient servers, the challenge here is to reduce energy cost and improve energy efficiency of DBMSs while maintain the performance levels that are accepted by users.

The purpose of query processing in a distributed environment is to form a high level query on a distributed database, which is seen as a single database by the users, into an efficient execution strategy expressed in a low level language in local databases.

In data Centers the databases are one of the major energy-consuming components in a data center, constructing green database systems to save energy and improve energy efficiency has become research hotspots in recent years. Energy management has been a significant aspect in designing and implementing green database systems.

The primary goal of traditional database is performance, which means to run the query faster without taking energy cost into consideration. Therefore the goal of green database has been shifted to energy aware query Processing and query optimization. To realize the goal the query optimizer should be energy aware of all the plans of a query and be able to select the desired plan that saves energy during query processing.

In Database management system, each query

Consists of set of many basic relational operation AND each query plains a unique path to execute a series of relational operators. As shown in Fig.1

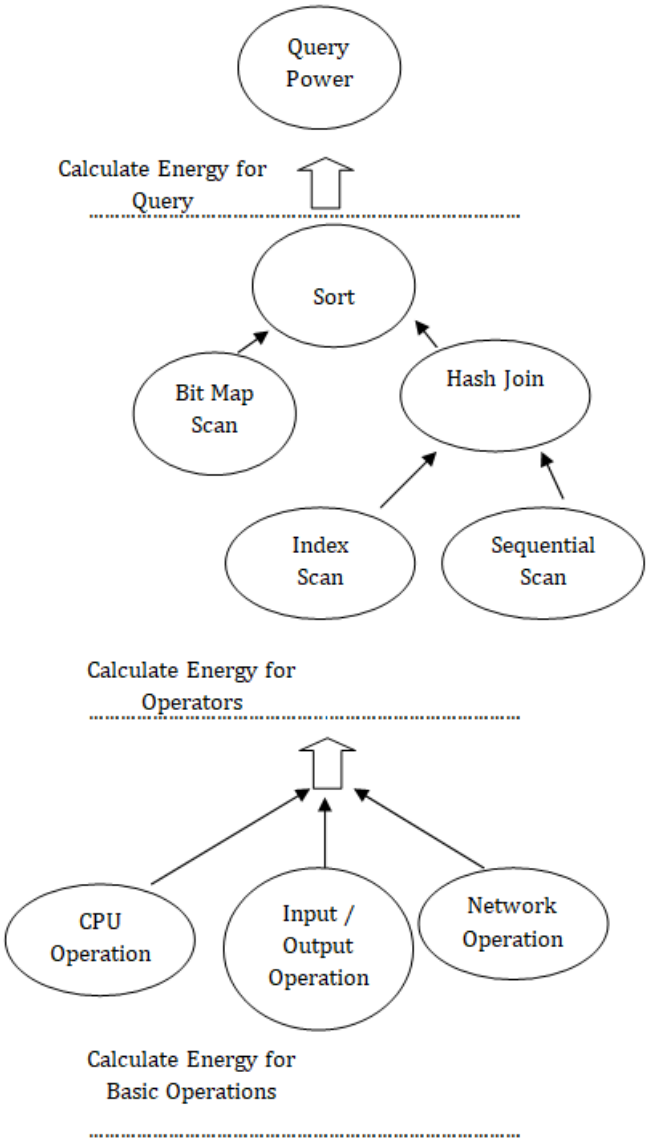

Fig-1: Query plan in Database Management system

Traditional database systems result in high energy consumption and low energy efficiency due to the lack of

consideration of energy issues and environmental adaptation in the design process.

Almost all IT Company focus on driving down the cost of IT equipment in the data centers. This was a reasonable assumption during the 90's when server power and energy costs were substantially lower, now a day's power density has been increasing at an alarming rate.

A recent re-port showed that when considering only the servers in datacenters, in 2015 an estimated 1.2% of the total U.S. energy consumption is attributed to powering and cooling servers, at an estimated cost of $2.7B. Another report by the EPA estimates that in 2016, the servers and data centers in the US alone consumed about 61 billion kilowatt-hours (kWh) at a cost of $4.5 billion, which is about 1.5% of the total U.S. electricity consumption. If the current methods for powering servers and data centers continue, then it is predicted that this energy consumption will nearly double by 2021.

In this study:

1) We describe the energy consuming for database in different data center.
(2) Some recently developed energy saving techniques in data management.
3) Describe the different method used to evaluation of energy-efficiency solutions.

2. RELATED WORK

This estimate is partially spurred by the revelation that from 2011 to 2012, global DC energy consumption increased by 19%. In North America this rate slowed to a 6.8% increase in power consumption in 2013. Even so, DCs are still estimated to consume over 100 billion kWh of energy per year in the U.S., more than 2% of overall electricity use [1]

The proportion of electricity cost in today's large-scale data management systems (typically, a data center) is increasing year by year In the United States, electricity consumption of data centers in 2011 accounted for 2% of the total national power grid [2].

Environmental problems caused by increasing energy consumption around the world have prompted the government to supervise the IT capacity of enterprises in the world. ICT industry has a very significant role to play in reducing greenhouse gas emissions, especially in a rapidly developing country such as China. Many industries can make use of modern ICT technology to move into higher efficiency low carbon markets [3].

Data center cannot control the use of energy, and the cost of electricity has begun to exceed the cost of hardware (Rasmussen, 2011), which has a negative impact on the density, scalability and related environmental design of data centers [4]

During the eight-year period the performance has increased 75 times or, in other words, the servers are providing 75 times more performance now for the same hardware cost of eight years ago. In addition, the performance per Watt has increased 16 times during the same period. Thus, for every unit of energy, the customer is getting 16 times the throughput as they did eight years ago. Roughly the performance/Watt of a server doubles every two years. [5] Study constructed a power consumption model based on the smallest units of resource consumption of queries. It reduces the processor energy consumption by 49% of the original consumption while increasing the response time by only 3%. On MySQL, it can reduce energy consumption by 20% with a response time penalty of only 6%. [6]

The relationship between energy consumption and performance of the DBMS is controversial. It first characterizes the power-use profiles of database operators under different configuration parameters. It also find that common database operations can exercise the full dynamic power range of a server, and that the CPU power consumption of different operators, for the same CPU utilization, can differ by as much as 60%. [7]

A bottom-up model to used in data center electricity demand in the United States over 20 year duration and examines observed that the projected electricity use trends in the context of changing data center operations. It show that the rapidly increasing electricity demand and use of about 70 billion kWh in recent years. [8]

Energy issues of database servers have recently draw attention from some well-known journals and conferences in the database field, such as EDBT 2008 [9], VLDB 2011 [10], SSDBM 2011 [11], EDBT 2011 [12], IEEE Data Engineering Bulletin 2011 [13], and IEEE Transactions on Computers [14].

3. ENERGY-EFFICIENCY FUNDAMNTALS

In this section we describe relationship between the energy and efficiency.

3.1 Energy v/s Efficiency

Energy is defined as:
Energy = Power × Time
Where Energy is measured in Joule and Power is measured in Watt

Energy efficiency is equivalent to the ratio of performance to the power used [15]
Efficiency is defined as:
Energy Efficiency = Workdone / Energy

Energy Efficiency = Workdone / (Power ×Time)
Energy Efficiency = Performance / Power

There are two ways to boost energy efficiency: either to increase performance with the same power or to reduce the consumption of electricity.

3.2 Improve Energy Efficiency

There are several ways of enhancing energy efficiency that can be taken.
a) Device Components Thorough Review
b) Reducing Power Level
c) Understanding and Measuring System Performance.
d) Adopting hardware modules for Power-Manageable
e) Constructing Energy Optimizers
f) Building Power Models for Computing Systems. [15][16][17]

4. EFFICIENT ENERGY DATA BASE MANAGEMENT AT SERVER SIDE

Server-side effective energy database management considers two major operations, first Query processing and second Query optimization. [18]

4.1 Software Side

In energy query analysis and optimization, data management software plays an important role. Usually, a query has several potential execution strategies, and the process of selecting an appropriate one for processing. The purpose of the query optimizer framework is to construct an execution plan, and the code generator produces the code to execute the plan. The runtime database processor is tasked with running the query code, in either compiled or interpreted mode, to generate the output of the query. Typically, determining the optimal method only takes time. In the current scenario finding the optimal Path is based on time as well as energy. Mostly three types of approaches used for minimizing energy in DBMS.

a) In order to increase energy efficiency, upgrade software components to decrease energy usage, reduce line of code, and compromise certain resources. In order to leverage database aggregation, the Enhanced Database Energy Efficiency incorporates the explicit delay mechanism used.
b) Cumulative use of computational resource shifting and data relocation to combine resources in space and time. If the resources are unused or not completely used, the device assigns other tasks to complete resource use or allows the resource to enter a sleep mode to save energy.
c) In conventional DBMS, optimization based on energy knowledge leads to high energy consumption and poor energy performance due to the lack of consideration of many energy problems and environmental awareness in the development process, query processing and query optimization.

4.2 Hardware Side

Lang et al (2009) proposed a mechanism for PVC (Processor Voltage/ Frequency Control) to evaluate energy output consumption. Its main objective is to execute instructions by leveraging the capacity of modern processors at a lower processor voltage and frequency. Basically, there are two modes of CPU frequency modulation, P-state switching and under clocking. In P-states, the CPU multiplier and CPU voltage settings are combined. Under clocking has been seen to exhibit the ability to fine tune the CPU speed by slowing the FSB speed. Lang et al (2009) adopted an under clocking method to modulate the CPU frequency, commercial DBMS, and MySQL has been experimented and shows that PVC mechanism is obliging.

5. EFFECT OF MEMORY ON PROCESSING QUERY

Its primary goal is to execute instructions at a low processor frequency and voltage by exploiting the capabilities of modern processors. So the performance of queries is significant role on memory. Memory also has a direct impact on the resources consumption of two other important components: CPU and disk. Memory structure in a traditional DBMS like Oracle DBMS has three main cache structures: Fig.2 Database Buffer Cache, Dictionary Cache and Library Cache. [19]

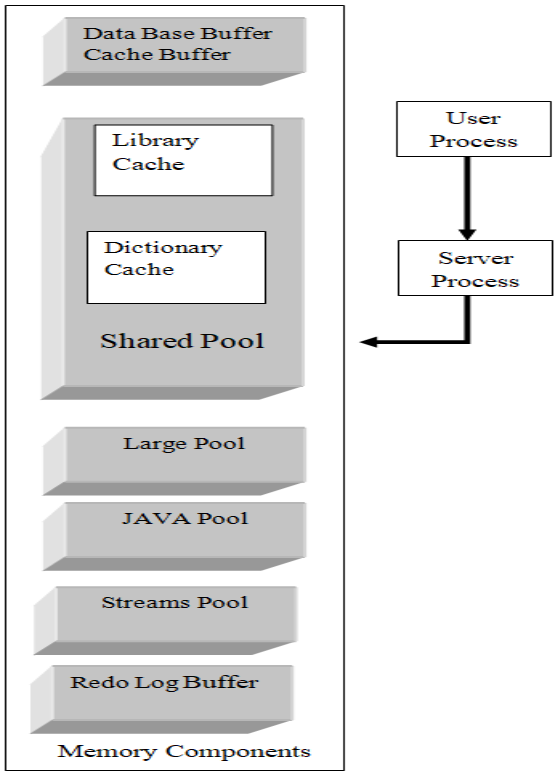

Figure-2: Memory Components

a) Database Buffer Cache:
Reading data from disk is very slow compared to memory. Therefore the query processing speed up database Buffer cache is used for cache data retrieved from disk. Database Buffer Cache is a memory area which contains a number of data blocks, and these blocks store copies of the data blocks in the data files of the DBMS. As the core operation in database application is to access and manipulate data, by using the least recently used (LRU) algorithm.

b) Library Cache
Library Cache is composed of Shared Pool Area (SPA) and Private SQL Area (PSA). In DBMS each Query has a Shared Pool Area (SPA) and Private SQL Area (PSA). A SPA holds query parse tree and query plans for a specific query. When multiple users are running the same query, SPAs is reorganized to let the users reuse the specific SPA and hold a copy of the query statement in their PSAs.

c) Dictionary Cache
A data dictionary is a collection of descriptions of the data objects or items in a data model for the benefit of programmers and others who need to refer to them. If a query had to be parsed data dictionary needs to be rapidly and frequently accessed to retrieve statistical data of the system and objects in database.

6. CONCLUSION

In this survey, we present Energy Usage, efficiency and Performance for Database Management Systems in a Data Center. The definition and challenges of an energy efficiency problem for a database management system in data center are also identified. We also focus on energy efficient data management at server side. We describe the effect of memory on the processing of queries through different caches. We assume that our study has high technological significance and it is a major factor in creating energy-efficient database systems and serves as the basic element for energy-aware query processing and query optimization.

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