INTERNATIONAL JOURNAL OF RESEARCH IN COMPUTER APPLICATION & MANAGEMENT

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MULTI COLONY ANT OPTIMIZATION: A NEW APPROACH TO QUERY OPTIMIZATION IN DISTRIBUTED DBMS

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ABSTRACT

In present situation, after the successful implementation of distributed environment in databases, there is a need to focus on query optimization cost. From past many years, various optimization algorithms have been used in the implementation of query optimizers. Every algorithm has its own effect in query optimization process by means of producing result in specific time. This time relates to cost, which differs in different type of algorithms. Many factors affect the cost of query optimizers in Distributed databases. In every optimization method, the emphasis is being given to implement methods for retrieval of the data in minimal time. This cost somewhat shows dependency on transferring of data on various sites, transfer the minimum amount of intermediate data may help in reducing cost. This cost impacts the overall performance of a system throughout the processing. In this paper, various methods have been discussed to know the significance of Multi colony Ant Optimization Algorithm. In past years, when database was centralized, there was no need to discuss cost related to transfer of data. But in distributed databases, emphasis is given here in this paper to find out a method which incurs minimum cost when there is a requirement to transfer the data within multiple sites.

KEYWORDS

optimization cost, query optimization process, swarm optimization.

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1. INTRODUCTION

Query Processing is a scientific approach of obtaining the desired information from a database system in a predetermined fashion. In large distributed environment, it is difficult to produce efficient database query plans based on information available solely at compile time. Getting the results of a query in time is the technique of Query Optimization (G. R. Bamnote and S.S. Agarwal, 2013, pp 53-56). It is used to find out the best order which results in optimal solution. In distributed databases, it can be considered as an emerging issue in current time scenario due to multiple sites participating in a single query. The retrieval of data is performed through various low -level operations such as project, join, select, cartesian product, etc. The primary goal of query optimization is to get the results faster, which motivates the need for creation techniques that results in faster execution.

A query is submitted in structured form which is converted into relational algebra operations. The optimizer chooses the best option from many alternatives available, for effective evaluation plan. The evaluation plan includes select, project operation but if more than one relation is included in a query then join relation has an important role to calculate the best plan (Michael Steinbrunn, Guido Moerkotte and Alfons Kemper, 1997, pp 191-208). The plan thus chosen always leads to an optimize result which depends on many factors. (Anjali and Sangeeta, 2016, pp 1608-1611). These factors affect the performance of optimizers such as number of sites involved and number of relations involved in join operation. Many researchers are working on query optimization problem to find out the best way to give the best join order. In this paper, some of the query optimization algorithms are reviewed to know the significance of each algorithm.

2. OBJECTIVES OF THE STUDY

In Query Optimization process, whenever a query is submitted, optimizer analyzes the Structured query language (SQL) and generates one or more query plans. These query plans executes the same query and optimizer suggests the execution method that gives the result in minimum time. In order to reduce the cost of query, an efficient algorithm is required in query optimization process. Many algorithms have been used so far in query optimization process so here in this study emphasis is given on to find out the efficient algorithm which helps in reducing the query optimization cost. The objectives of this study includes-

1. To study and analyze the algorithms used in query optimization process in Distributed Database Management System.
2. To find out the limitations of algorithm based on review.
3. To show the significance of Multi Colony Ant Optimization algorithm.

3. PROBLEM IDENTIFICATION

Query optimization problem relates with the cost associated with the query. The optimization of these expressions can be carried out optimization algorithms such as Deterministic algorithms, Randomized algorithms and Genetic Algorithms

Deterministic algorithms start from base relations and build plans by adding one relation at each step. Every algorithm in this class constructs a solution step by step in a deterministic manner such as Dynamic Programming, Iterative Dynamic Programming etc. Randomized Algorithms use random numbers or random walk to decide the series of moves. Randomized algorithms such as Simulated Annealing and iterative Improvement are the most used algorithms for optimization problem (Yannis E. Ioannidis and Younkyung Cha Kang, 1990, pp 312-321). Genetic Algorithms are bio-inspired algorithm which works on the behavior of chromosomes and genes. Data stored on various locations are in huge size and for extraction of information from the databases dispersed on various site, various algorithms has already implemented but challenge is to reduce the total time in the extraction of data. In this research work, the focus is on to reduce the time taken for execution of query.

4. ALGORITHMS ANALYZED FOR QUERY OPTIMIZATION IN DISTRIBUTED DATABASE SYSTEMS

Query processing is the process of translating a high level query (relational calculus) in a sequence of database operators (relational algebra +communication operators). User does not need to specify the procedure of accessing the data. The role of query optimizers is to transform the query by selecting the most efficient one which assures correctness in any DBMS. As the data is growing bigger in distributed environment, the algorithms which have been designed needs modifications. Several algorithms such as Genetic algorithm, Dynamic programming and various swarm intelligence algorithms have been used in the area of optimization from past many years. Swarm Intelligence has been evolving as an active area of optimization over the past years. The major emphasis is on to design adaptive,

decentralized, flexible and robust artificial systems, capable of solving problems through solutions inspired by the behavior of social insects. During this research work, several algorithms were studied for the solution of the optimization problems. Some of these algorithms are as follows:

a) GENETIC ALGORITHM

Based on bio-logical inspiration, Genetic algorithm works on initial population which was chosen randomly. Each member in a population represents a possible solution to the problem at hand and is commonly called a chromosome. Here each solution (chromosome) is evaluated according to an evaluation (fitness) function. During selection operation, members of the population (parents) are selected in pairs to produce new possible solutions. The fitter a member of the population, offspring will be produced by random crossover and mutation. These offspring are then evaluated and replaces the weaker memebers of the previous generations (Wenjiao Ban et.al., 2016; S. Venkata Lakshmi, Valli Kumari Vatsavayi, 2016; Ender Sevinç and Ahmet Coşar, 2011). It gives out the solution by following many steps. In the very first step, the algorithm starts with an initial population which is usually chosen at random and contains a wide variety of members. Here, population's each member represents a possible solution to the problem at hand and is commonly called a chromosome. This phase is commonly called up as initialization phase. After populating the data, a fitness function evaluates each result. This phase is used to find out the feasible solution. During natural selection phase, members of the population (parents) are selected in pairs to produce new possible solutions. The fitter a member of the population, the more likely it is to produce offspring. Verification is used to be done by crossover operator. It is then used to result in offspring inheriting properties from both parents. The offspring is evaluated and placed in the next population, possibly replacing weaker members of the last generation. Mutation operator is used to allow further variation of offspring. The problem is considered to be solved if the solution is close enough to the desired answer. Otherwise the same process will be repeated until a solution is reached. Complexity is one of the limitations of genetic algorithm. It does not assure constant response time. (Jiunn-Chin Wang, 2002) The difference between largest optimization time and smallest optimization time is much bigger.

b) DYNAMIC PROGRAMMING

Dynamic Programming approach works in bottom-up manner to find the solution in minimum cost. This behavior of this approach was compared with other algorithm to show the significance of this algorithm (Ismail H. Toroslu and Ahmet Cosar,2004, pp 149–155). A good framework was design by Jeff Sidell to work on dynamic optimizers (Jeff Sidell, 1997, pp 1-19) A good idea was again brought to run the query in dynamic query optimizer with full replication. Various factors were included that affects the distributed environment (Robert Taylor, 2010). Chung and Irani suggested an approach which minimizes the intersite data traffic incurred by a distributed query by using a sequence of semi joins. A method was developed which accurately and efficiently estimates the size of intermediate result of a query. A heuristic algorithm was developed to determine a low cost sequence of semi joins (Chung and Irani,1986, pp. 137-157; Sunita M. Mahajan and Vaishali P. Jadhav 2013)

Dynamic programming algorithm is used for optimization (for example, finding the shortest path between two points, or the fastest way to multiply many matrices). Dynamic programming algorithm always checks the options to solve the problem and picks the best solution and always guarantees the optimal solution. From past many years, researchers are focusing on swarm intelligence technique which has been proved to be a good technique in query optimization. Swarm intelligence deals with the problem by analyzing the problems as insects or animals to solve complex problems. Some commonly used swarm intelligence algorithms for the solution of the optimization problems include Ant Colony optimization (ACO), Particle Swarm Optimization (PSO) and Artificial Bee Colony (ABC). Optimization phase in these three algorithms can be implemented by the behavior of agents (Ismail H. Toroslu and Ahmet Cosar,2004, pp 149–155). The only problem with this method is that it creates complexity in programming and does not calculate the actual cost associated with join queries.

c) ANT COLONY OPTIMIZATION ALGORITHM

ACO was proposed by Dorigo and Gambardella and it is a population-based swarm intelligence algorithm. This algorithm analyzes the behavior of ants and their searching strategy. It was designed basically for working on TSP (Travelling Salesman Problem). These ants builds their solution step by step by updating their pheromone value on every available path. The value of pheromone deposits decides the route for other ants on path. Result can be achieved by going through many phases. In Initialization phase, parameters and pheromone trails are initialized, ant solution are constructed. Colony of ants concurrently and asynchronously visits adjacent states of the problem by moving through neighbor nodes of the problem's construction. They move by applying a local decision policy that makes use of pheromone trails and heuristic information and builds their solution. After building a solution, or while the solution is being built, the pheromone updation depends on partial solution. Pheromones values get updated in pheromone updation process. In the next phase, a short path, by comparison, gets marched over more frequently, and thus the pheromone density becomes higher on shorter paths than longer ones. Pheromone evaporation is also an important phase due to convergence of solutions. The quantity of pheromone decides the probability of ant trail on that path and thus produces the good solution. Then, in verification stage, current solution will be replaced with a new generated solution if it is not easy to be found. Ant colony will not stop repeating the steps above (except the initial stage) until maximum iteration or a minimum criterion is attained. (Jeff Sidell, 1997, pp 1-19)

d) PARTICLE SWARM OPTIMIZATION ALGORITHM

PSO (Particle Swarm Optimization) was proposed by Kennedy and Eberhart and is a population-based swarm intelligence algorithm. As ACO is inspired by the behavior of ants, PSO is inspired behavior of birds. Birds, which forms the solutions, always take space towards better solutions. These movements are the result of previous solutions in the form of best results (Robert Taylor, 2010). In population Initialization Phase, a problem is given, and some way to evaluate a proposed solution to it exists in the form of a fitness function. In the Initialization phase, problem solutions are defines randomly in the form of candidate solutions. In the next step, an iterative process to improve these candidate solutions is set in motion. Fitness of candidate solutions is then evaluated. The local best solution is evaluated and then shares the information to their neighbors of their success. Population movement is guided by the success of local best solution. In natural selection phase, every particle produces a local solution. Neighboring particles influences by the best solution of particles by gaining their position and own experience. In case of neighborhood of a particle is the entire swarm, the best position in the neighborhood is referred to as the global best particle and thus gives the best optimal solution. Each paricle's solution is evaluated with the fitness function (Chung and Irani, 1986, pp. 137-157). This optimization method does not work with non-coordinate system. It finds out the optimization partially which affects the speed and direction.

e) ARTIFICIAL BEE COLONY ALGORITHM

In the Bees algorithm, every food source represents a possible solution whereas the nectar amount represents the quality of source. The number of employed bees is exactly equivalent to number of food sources. In Initialization phase, employed bees are associating with food sources (solution). In iterative process, every employed bee checks the neighboring food source and evaluates its nectar amount (fitness) (Sunita M. Mahajan and Vaishali P. Jadhav, 2013). All the bees are scout bees who seek randomly food sources near the bee hives in initialization phase. Half of the bees find food source and becomes employed bees, where these bees either spread information or give up the found food source and becomes scout. Here some solutions that don't meet the constraint condition will be replaced randomly. In Natural Selection phase, some bees becomes onlookers who does not get any food source and waits for the employed bees to provide them the information of food source. After getting the food information, the fitness is evaluated to get the better solution. In verification phase, if the number of failure time than maximum limit then onlooker bee gives up the current food source. Here, if the current solution is not easy to be found and then it will be replaced with a new generated solution. The process will repeat all the phases until maximum iteration or minimum criteria are attained. (Yannis E. Ioannidis and Younkyung Cha Kang, 1990, pp 312-321)

In our dynamic approach of query optimization, we consider each preferred path which a bee takes is a complete QEP (Query Execution Plan) which passes contains all relations. Each bee exchanges the result with its neighborhood for finding the better QEP. The area of query optimization is very large within the database field. The limitation to this method is that it does not have information about sources on prior basis. It is slow as compare to ACO. It requires good memory capacity. Query optimization is a crucial part in deciding the total time taken by optimizers. Current optimizers are working efficiently for lesser number of joins but if the number of joins are more, then these algorithms gives output in comparatively big amount of time. Many researchers are working on this same problem from past many years. Many papers are reviewed during the first phase.

f) MULTI COLONY ANT OPTIMIZATION

The quality of ACO is to deal with complex problems where the task is to get the best solution out of many possible solutions to a given problem. This algorithm can get a good solution at the early stages of the algorithm execution. As the data is distributed over multiple sites, an efficient mechanism is essential to search

for the relation which is going to be used in implementing the solution of a query. ACO is the good mechanism to extract the data for further processing but a new method of multi colony is being proposed in this paper for more effective output with comparatively lower cost. In this method several ant colonies participate in a single query and the colony with best output is chosen for the processing of query. The criterian for choosing the best output is again the cost for extracting the result of query. The colony which gives the result in minimum time with accuracy may be taken as the first set of result. This method may be proving to be very effective as the multiple colonies are working on single query simultaneously (Ladan Golshanara et. Al, 2014, 1-46).

To improve the performance of ACO algorithms, Multi colony ant algorithm is the method that explores the large area of the search space and optimal solution. In this algorithm, a group of several colonies of ants cooperate in order to find good solutions for the problem being solved [8]. Multi colony ant algorithms is the most commonly used algorithm to solve multi-objective problems specially implemented for parallel computing environment, where p colonies run in p parallel processors. Only the best solution is considered in migrate best solution step. Each colony uses its best so far solution to update the pheromone trail equal to the quality of the solution.

5. SIGNIFICANCE OF MULTI COLONY ANT OPTIMIZATION IN QUERY OPTIMIZATION

Ant colony optimization algorithm deals with combinatorial optimization problems, including travelling salesman problem. It works better than bee colony optimization as it gives higher performance based optimal solution. Therefore, the ant colony optimization is better based on algorithm in detecting spam. Swarm intelligence algorithms such as Ant Colony Optimization (ACO), Particle swarm optimization (PSO), Artificial bee colony optimization (ABC) are some of the optimization algorithms which may help researchers to devise a new solution for the current problem. ACO takes decision on the basis of behavior of natural ant colonies which optimize their path from an origin (ant nest) to a destination (food source) by taking advantage information acquired by ants that previously traces all the paths based on pheromone deposition and these ants leave behind as they traverse the paths to optimal solution. Route of ants are prepared by the pheromone trails to construct complete solution. This effect is called dynamic positive feedback and helps speed convergence of ACO. (Robert Taylor, 2010) As the data is distributed over multiple sites, an efficient mechanism is essential to search for the relations which are going to be used in implementing the solution of a query. ACO is the good mechanism to extract the data for further processing but a new method of multi colony is being proposed for more effective output with comparatively lower cost. In this method several ant colonies participate at each site in a single query and the colony with best output is chosen for the processing of query. The criteria for choosing the best output are again the cost for extracting the result of query. The colony which gives the result in minimum time with accuracy may be taken as the first set of result. This method may be proving to be very effective as the multiple colonies are working on single query simultaneously. (Chung and Irani, 1986, pp. 137-157)

6. CONCLUSION

Swarm Optimization is gaining attention of researchers from the last decade. Every algorithm has its own qualities. But the well-known ACO algorithm is one of the most effective swarm-based algorithms to find out the result of query in minimum time. In today's scenario when data is not kept at single place, the dispersed data needs to get processed in order to get a simple query result. To find out the result of query on multiple sites, MCAO, an advanced form of ACO can be utilized. So, the method of MCAO may prove to be a good implementation to work in parallel manner. It implements parallelism in ACO thus giving the results in shorter amount of time as comparable to ACO.

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