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QUERY PROCESSING AND RESOURCE ALLOCATION IN COMPUTER NETWORKS

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By

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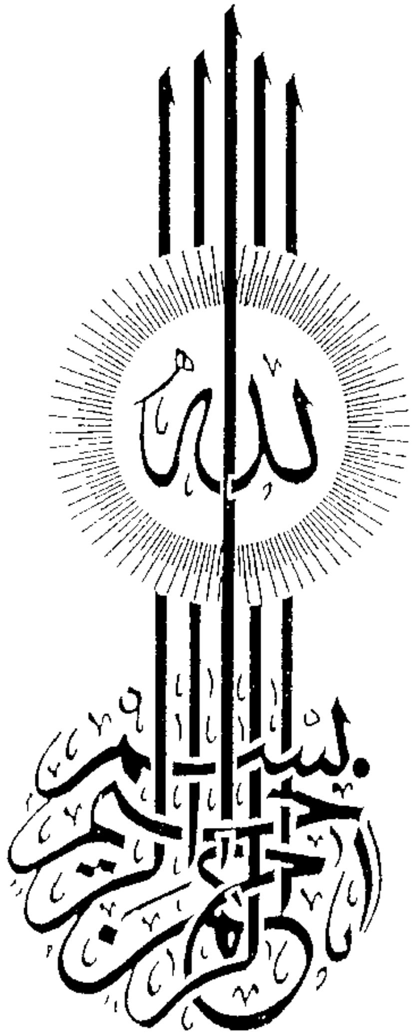
بسم الله الرحمن الرحيم

"Nobody, nothing, but his own destiny, can stop an ambitious, decisive human being from going through the ways he wants ... when he wants"

To my father and my mother who, for so long, have been waiting for this moment ...

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ABSTRACT

This thesis can be logically divided into two interrelated parts. The first part proposes a queueing model general enough to represent query processing in a DDB system, and to measure its performance criteria. By means of this model, it is possible to measure criteria as response time, throughput, mean population (in queries). Comparison between the different query processing algorithms is also achievable in a systematic and clear procedure. The inclusion of the paths to be involved in the processing of the subqueries of a given query, is done according to specified steps. The effects of the work conditions of the network on the query processing algorithms are easily considered by the proposed model. Various case studies have demonstrated that the solution method of the model is computationally efficient.

The second part of the thesis suggests and presents a graph theory based allocation algorithm suitable for both static and dynamic allocation of resources. A fair allocation of nodes and lines, as well as a determination of the number of DDB copies are obtained and clarified by representative case studies within acceptable storage and computation time needs. Constraints as reliability, response time and cost are considered. Different allocations for the same problem are easily attainable, allowing thus a convenient selection of one of many possible alternatives. Each selection suits a specific network circumstance, such as work hours of the day, priority queries, etc. Also, both static data (queries without updates) and dynamic data (queries with updates) can be easily accommodated.

CHAPTER 1

INTRODUCTION

Query processing and resource allocation are two basic aspects of Distributed Database systems (DDB's). Although studied separately in the literature, these two aspects are interrelated and interdependent. A query processing algorithm must ensure fast processing time as well as low communication cost. Such objectives cannot be attained without selecting well located data, which implies that database partitions should be spread over "processors" (nodes) "linked" in a way which guarantees a minimum level of acceptable reliability, of affordable communication cost and of on limits query response time. Such distribution of data and assignment of processors and lines is a resource allocation job. As the dependency of the query processing algorithm on the resource allocation has been made clear, the other dependency side should also be presented. A resource allocation algorithm cannot provide realistic results without being fed with the number of DDB partitions and the required query response time.

In this thesis, an attempt has been made to relate the query processing and the resource allocation problems. Without proposing a new query processing algorithm, we present a "queueing model",general enough, to represent query processing, and to measure its performance criteria. Criteria as response time, throughput, mean population (in queries) are measurable. Comparison between the different query processing algorithms is also achievable in a systematic and clear way. Paths to be involved in the processing of the subqueries of a given query are selected according to specified steps. Line and processor utilization are calculated, so is the share of each query class from the processing capacity (power) of the processing node and line. Furthermore, the effect of the operation conditions of the network on the query processing algorithms can be easily considered. Briefly, our model considers, in a reasonable period of time, the effects of various "allocations" of lines and of processors on the query processing performance, while considering the operation circumstances of the network.

Based on graph theory principles, the thesis suggests and presents a "resource allocation" algorithm suitable for static and dynamic assignments of resources. Due to its high storage and computation time needs, graph theory has been avoided throughout previous resource allocation studies. But, within a limited computation interval and reasonable storage requirements, the proposed allocation algorithm offers a resource allocation, determines the number of DDB copies and specifies alternate data locations. Graph theory offers a better insight and feeling of the network structure, while considering performance constraints such as reliability, communication cost and query response time.

This thesis is organized as follows:

Chapter 2 deals with the different query processing approaches in a DDB environment. General problems related to query processing and to data distribution are treated. The specific problem of query optimization is then discussed and the basic criteria of algorithms proposed by different researchers are presented.

In chapter 3, our proposed queueing model is described, with special stressing on case studies demonstrating its efficiency and credibility.

Chapter 4 demonstrates the resource allocation problem. The problem considerations, constraints and solution methods are introduced through a survey of the research work conducted in this domain in the past years. A comprehensive comparison between the proposed allocation algorithms permits a mature understanding of their capabilities and limitations, and leads to an explanation of the allocation algorithm to be presented in the chapter to come.

A graph theory based allocation algorithm suitable for both static and dynamic allocation of resources is proposed in Chapter 5. A fair allocation of nodes and lines as well as a determination of the number of DDB copies are obtained and clarified by representative case studies within acceptable storage and computation time needs. Constraints as reliability, response time and cost are considered. Different allocations for the same problem are easily attainable, allowing thus a convenient selection of one of many possible alternatives. More than one allocation may be adopted depending on the network circumstances and the work hours of the day. Also, static data (queries without updates) and dynamic data (queries with updates) can be easily considered.

Chapter 6 summarizes once more the thesis results, and foresees what may be next.

In order to categorize the references according to their topic, and to permit an easy access to them; each chapter is followed by an alphabetically ordered list of the related references.

It should be mentioned that the computational results were obtained using the available INTERDATA 7/32 mini-computer with a 16 Mhz main clock frequency.

CHAPTER 2

QUERY PROCESSING: CONSIDERATIONS, STRATEGIES, OPTIMIZATION

2.1 INTRODUCTION

This chapter deals with the query processing approaches in a DDB system. First, general problems related to query processing are emphasized. The impact on data retrieval of the overall architecture of the DDB, of the data distribution criteria, and the characteristics of the data dictionary are analyzed. The specific problem of query optimization is then discussed, and the basic criteria of algorithms proposed by different authors are presented.

2.2 DDB ARCHITECTURE AND QUERY PROCESSING

2.2.1 Query Processing in a DDB system

Query processing in a DDB system corresponds to the translation of requests formulated in a high level language on one computer of the network, into a sequence of elementary instructions which retrieve data stored in the distributed database.

A possible reference architecture is shown in Figure 2.1, where the evolution of a query is represented. A four level DDB which suits a distributed environment is shown in [ANSI/X3/SPARC DBMS proposal;1977]. In that report three levels of data representation were indicated, corresponding to the external, conceptual and internal schemata (plural of schema); such representation applies to a centralized environment. In a distributed environment, the need for a global conceptual schema which represents an integrated view of all local conceptual schemata, is imposed in [Neuhold & Biller;1977] ,and [Adiba & Portal;1978].

The evolution of a query corresponds to a sequence of translations towards the internal schema language. The main software modules which implement this evolution are shown in Figure 2.1, the specific problem of optimizing query decomposition will be analyzed in Section 2.3.

The global software architecture of Figure 2.1 may be subdivided into two parts, linked by the communication network. the lower part of the architecture corresponds to the functions of a local DBMS; the upper part includes functions like supervision, distribution, and control of operations directly related to the distributed environment.

This approach, where local DBMS's perform functions which are characteristic of a centralized database, allows to focus the DDB project only on the design, planning and development of the software which implements the upper part of the architecture; this approach is followed in most of the existing DDB systems, as SDD-1 [Rothnie & Goodman ;1977], COSYS [Adiba & Portal;1978], and SIRIUS/RNUR [Gardarin,G. et al.;1977].

In SDD-1 the two parts are called local data manager (LDM) and global data manager (GDM). Each GDM may interact in any way with other GDM's or LDM's; interactions between GDM's are therefore allowed at a supervision level, with possibly more than one supervisor for each query.

A simpler approach, adopted in the ADD system [Mahmoud,S.A. et al.;1979] as discussed in Section 2.5, assumes that for each translation only the computer on which the query has originated coordinates the access to each local database.

The optimization process produces to the local databases a sequence of operational commands. Each command corresponds to operations which must be performed on the local and remote