Towards Quality-of-Service Support in Multimedia Database Management Systems

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1. INTRODUCTION AND MOTIVATION

It is commonly accepted, that the Quality of Service (QoS) concept is of central importance for distributed multimedia systems [6]. From the communications point of view, the main concern is how to support QoS requirements by networks, protocols, and operating systems. However, with respect to QoS in multimedia systems it is necessary to consider more than communication system and operating system, because most multimedia systems do not only manipulate and transmit multimedia data. Additionally, they store and retrieve multimedia data, and present them in a proper way to the user. However, the relevance of database management system (DBMS) aspects for QoS in multimedia systems has not been broadly recognized [2].

It is the aim of this poster, to present the ongoing work on QoS support in multimedia DBMS (MMDBMS) at UNIK - Center for Technology at Kjeller, University of Oslo and to discuss this topic with ACM MM'98 participants. The reminder of this abstract is structured as follows: the next section describes the application-oriented DEDICATION (Database System Support for Distance Education) project at UNIK in order to illustrate the usage and benefits of QoS support in MMDBMS. Afterwards, we outline our research activities that are concerned with design and implementation of a MMDBMS with QoS support.

2. DEDICATION

The so-called *electronic classrooms* are used since several years to distribute lectures between different sites at the University of Oslo in real-time (i.e., for synchronous teaching) [4]. In the DEDICATION project, we are aiming at DBMS support for asynchronous teaching. All transparencies and scanned images that are used in the lecture, the interactions with the whiteboard in the classrooms, as well as video and audio streams from the different classrooms are separately stored in a multimedia database system (MMDBS). This separate modeling and storing of different multimedia data types allows to retrieve the data independent of each other, e.g., reading the transparencies of the first hour of a certain lecture. Furthermore, the entire lecture, i.e., all multimedia data types and corresponding data elements, can be reproduced: audio and video streams from all classrooms are continuously retrieved and their presentation to the user is synchronized with retrieval and presentation of transparencies and interactions with the whiteboard.

Obviously, queries are defined by the user to communicate with the system which data elements have to be retrieved and presented. Furthermore, the queries contain QoS specifications for the different multimedia data types and/or data elements. QoS specifications are used to reserve the necessary resources and to appropriately schedule the MMDBMS tasks. Users that accept a lower QoS enable the system to save rare resources. In the following, we describe three typical scenarios for reduced QoS and outline their consequences for MMDBMS:

- **Reduced video quality**: this can be achieved with mechanisms that are similar to those that are used for media scaling: "drop" frames or enhancement layers. This means for query processing and storage management not reading all data from disk and transporting less data to the user. Thus, more resources like buffers, disk I/O bandwidth, and network bandwidth, are available for other tasks.
- **Reduced reliability constraints**: for example a student tolerates errors in the transparencies, because the student has already the handouts and only wants to recapitulate the lecture. Errors in the I/O devices, e.g., caused by bad blocks on a disk or damaged disks in a disk array can be ignored. Thus, expensive recovery operations are not necessary and resources are saved for other processes/tasks.
- **Relaxed synchronization requirements**: a student wants to get video, audio, and transparencies from the lecture. However, synchronization between the continuous media streams and transparencies is not important. Synchronization implies that different tasks have to wait for each other and scheduling gets more complex. Relaxed synchronization reduces these constraints and decreases the time that tasks spend in the system and occupy resources, e.g., buffer space.

In conventional DBMS, any data loss is prohibited by the transaction paradigm. In MMDBMS, however, loosing a video frame or even dropping it explicitly will still provide a "correct" result of the query (only quality is decreased) [5], [7]. Therefore, QoS specifications in MMDBMS lead to optimized resource utilization and/or better services.

3. IMPLEMENTING QOS IN MMDBMS

The research activities that are concerned with design and implementation of QoS in MMDBMS are mainly performed within the OMODIS (Object-Oriented Modeling and Database Support in Distributed Systems) project [1], which is funded from the Norwegian Research Council. Currently, we focus on the following three areas:

- **Data modeling and query processing** have to support the following four features: (1) It is necessary to represent arbitrary data types and specification of programs that interact with arbitrary data sources. This demands: object-oriented data modeling with special multimedia and QoS support, management of several kinds of magnetic and optical storage devices appropriate for multimedia data handling, uniform management of very large data volumes (management of tertiary storage) and multilevel storage hierarchies. (2) It is essential to be able to query and modify multimedia data with QoS specification, including retrieval of multimedia data via associative search within multimedia data. (3) The data model has to enable applications to specify and execute abstract operations on multimedia data, e.g., play, fast forward, pause, and rewind one-dimensional data like audio or text, and to display, expand, and compress two-dimensional data like bit-mapped images. (4) Query processing and optimization have to deal with heterogeneous data sources in a uniform manner, including access to data in the following sources: main memory, disks, disk arrays, optical disks, tapes; as well as migration of data between storage levels and data conversion.
- **Buffer management**: To support continuous playout of time-dependent data, reservations of the limited resources disk I/O bandwidth and network bandwidth have to be combined with appropriate buffer management. Based on the special requirements of DEDICATION, we have designed the buffer management mechanism Q-L/MRP [3]. Q-L/MRP is a buffer preloading and page replacement mechanism for multimedia applications with heterogeneous QoS requirements. Q-L/MRP extends L/MRP with two features: it supports multiple concurrent users, and it supports QoS with a dynamic prefetching daemon. This dynamic prefetching daemon is able to dynamically adapt to the changes in network and disk I/O load. Furthermore, QoS requirements from users, like frame rate, are mapped into the buffer mechanism. Our performance analysis shows that Q-L/MRP is very suitable for the special environment in DEDICATION and outperforms other buffer management mechanisms.
- **Storage management**: In the lower layer of MMDBMS, disk-head positioning, i.e., seek time and rotational latency, generally constitutes a large part of the service time of a disk request and reduces the efficiency. Striping of data elements over several disks in a disk array is often necessary due to high bandwidth requirements of multimedia data types, but this increases the amount of disk-head movement. Furthermore, switching between different streams in multi-user systems introduces additional disk-head positioning. Scan algorithms have been developed to schedule disk accesses such that the number of head positionings are minimized. However, scan algorithms are no ideal solution, because they reduce the predictability of the response time, and thereby make it harder to fulfil (guaranteed) QoS. Currently, we are working on alternative striping methods to reduce disk-head positioning work and its effect on the efficiency, and to increase predictability of response time.

4. REFERENCES

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