INTRODUCTION

Among the challenges of multimedia and mobile computing, providing a mechanism for data retrieval in multimedia databases under wireless mobile environments is one of the most difficult issues (Shih, 2001). Up to now, the fundamental technologies that are specialized for wireless mobile, multimedia environments are not mature in object-oriented, object-relational, as well as relational databases (Hillborg, 2002; Ramakrishnan & Gehrke, 2003; Watson, 2004). An important issue is how to ensure quick query response for the users. If a user found out that the retrieved multimedia object is neither interesting nor useful after it is displayed, then the time and bandwidth used for transmitting the multimedia objects have already been wasted. In order to save precious time and expensive bandwidth, it could be a good idea to let users browse objects at an acceptable resolution without paying much attention to the details or at the limited device display capability. This article presents a novel concept to deal with this problem by making use the concept of quality of service (QoS) to achieve adaptive query processing. In general, traditional QoS management is defined as the necessary supervision and control to ensure that the desired quality of service properties are attained and sustained, which applies both to continuous media interactions and to discrete interactions (Chalmers & Sloman, 1999). QoS thus consists of a set of specific requirements for a particular service provided by a network to users. However, little work has been done in extending QoS principles to multimedia data management in wireless network environments.

MOTIVATION

Since a traditional DBMS does not support QoS-based objects (Shih, 2002), it only concentrates on tables that contain a large number of tuples, each of which is of relatively small size. However, a multimedia database management system (MM-DBMS) should support QoS-sensitive multimedia data types in addition to providing all the facilities for DBMS functions. Once multimedia objects such as images, sound clips, and videos are stored in a database, individual objects of very large size have to be handled efficiently (Chang, Hung, & Shih, 2002). Furthermore, the crucial point is that mobile MM-DBMSs should have the QoS-based capabilities to efficiently and effectively process the multimedia data in wireless mobile environments.

Figure 1 depicts a scenario where a client degrades his quality criteria and obtains a coarse query result with his limited display capacity within the acceptable response time. Suppose the client with a currently available PDA device queries a University of Nebraska Peter Kiewit Institute (PKI) image in a multimedia database through wireless networks. The client uses a GPRS

Figure 1. Comparison of original and processed query image enhanced by extended QoS

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system to connect to the UMTS wireless network. The server uses a wireless LAN (Wi-Fi) to connect to the wireless network. There are two problems existing in the client site: (1) The display capacity is too low to present the captured image object (the original dimension is 490×269 pixels, while the screen can only accommodate 128×128 pixels); (2) Even if the client can solve the screen resolution problem, the response time is still a problem due to the “out of the upper bound” delay time.

Using extended QoS-enhanced query processing in MM-DBMSs under wireless mobile environments, both issues mentioned above can be solved. The basic idea is that we reduce the final quality of picture to 12% of that of original one for the compensation, so that we can obtain the simplified object size from 101 KB to 12 KB. In this case, the data transmission time could be possibly controlled within 60 ms (since $t = 64\text{KB}/512\text{KB} \times 50\% = 0.5 \text{sec}$). However, such kind of adaptive QoS mechanism still does not exist.

**BACKGROUND**

Numerous studies have been carried out for using QoS for mobile database query processing (Bordbar, Derrick, & Waters, 2002; Cao, 2003; Ecklund, Goebel, Plagemann, & Ecklund, 2002; Kazantzidis, 2002; Miloucheva & Tartarelli, 2002; Watson 2004). Note existing studies typically assume that all the QoS requirements are specified by users in advance. However, in multimedia applications, it is difficult to predict the size of the targeted object to be retrieved. Existing approaches usually stop the query if the required QoS conditions cannot meet the related statistical or empirical resource utilizations (Braumandl & Kemper, 2003). Apparently, stopping the query under an adverse condition is unreasonable restriction, and adaptive query processing should be supported. Consequently, a critical issue to be investigated is concerned with how to extend existing QoS principles to deal with wireless mobile environments for multimedia applications. Technologies for QoS-based query processing in mobile, multimedia DBMS are summarized in Figure 2. Extending query processing in MM-DBMSs to wireless mobile environment must consider the following: (1) Multimedia application, especially multimedia object retrieval, needs resource consumption often exceeding the available resource capacities of the deployed wireless/mobile networks and portable devices; (2) the precautions of these extra resource requirements cannot be taken by the server, the client, or even the network infrastructure in advance; and (3) we need to extend QoS management in a mobile environment to specify a range of acceptable QoS levels to allow for scaling of multimedia query processing, rather than trying to guarantee specific values or to stop the querying.

**A Quantitative Approach**

Based on these considerations, we have explored a new quantitative approach to achieve the trade-off between querying results and qualities according to application priorities and capacities, because QoS requirements are preferably described by using some quantitative figures. Instead of requiring a good network service, the user is asked to specifically request some measures such as connection speed or delay, which can be described by a numerical value, for example, 256 Kbps or 60 ms, respectively, for the speed and delay. Having a quality term such as good or bad described by a quantitative metric simplifies the process of allocation of that quality to a particular service by the provider and also prevents any possible ambiguity during the user request and service fulfillment process (Ganz, Ganz, & Wongthavarawat, 2004). We have explored an approach to tackle this issue by specifying a range of acceptable QoS requirements for multimedia query processing. We have proposed a QoS-based matrix to support adaptive query processing of object-relational multimedia databases in the context of wireless mobile environments. The proposed QoS-based querying processing precision matrix (QQPPM) is based on real-time QoS conditions in wireless networks, the multimedia database’s object properties, and mobile client-site data processing.