MobiSnap: Managing Database Snapshots in a Mobile Environment*

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Abstract

This paper presents MobiSnap, a research project that aims to support the development of SQL based applications for mobile environments, providing configurable support for data divergence control and connectivity abstractions. One of the project goals is to assist the migration of legacy SQL based applications into these new operational platforms.

1 Introduction

In recent years, advances in hardware and network technology enabled a rapid evolution of portable computers. Some of these advances can be seen in wireless and cellular communication, battery technology, and in the constant reduction of the dimensions, weight and energy requirements of many components [2]. This has led to a new generation of portable machines with different dimensions and capacity, ranging from small hand held devices with scarce storage and processing capacity to powerful laptop computers. Regardless of their size, most of these mobile computers are equipped with wireless connections, allowing access to static computers and even to other mobile devices. The widespread use of such computers creates a heterogeneous environment where mobile computing devices are ubiquitous.

Mobile computing paves the way to new classes of applications, exploiting not only the inherent portability and mobility of computer devices, but also the wide availability of

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communications. Information systems may be accessed from any place in order to query and modify data, opening new operational possibilities for a wide range of economic activities [3]. However, the distinct characteristics of mobile computing [4] demand novel solutions to old and new problems such as communication breakdowns, periods of disconnection and variable QOS of the communication infrastructure. In other words, mobile computing can not be regarded as a "scaled-down" version of the well-studied field of distributed systems.

Currently, most applications available for a broad range of portable computers consist of small utilities such as calendars and fax programs, and Internet-based programs such as e-mail programs and WWW browsers. The development of new applications for specific problems is largely dependent on the access to information servers. Most information servers have programming interfaces based on SQL. Unfortunately, no framework is widely available to help programmers to easily deal with mobility, including reduced, varying and even unavailable connectivity in such environments. As a consequence, programmers have to develop their own solutions from scratch over and over again.

Motivated by the lack of a generic framework, we have started a new research project, called MobiSnap , which is intended to provide adequate support to simplify the development of new SQL based applications for mobile environments. The MobiSnap system will ease the writing of mobile computer applications needing to access and update data stored in information servers, even when the mobile computer is disconnected. MobiSnap also will provide a framework aimed at dealing with the transitory divergence of the cached data in the mobile system and the corresponding one at the information server.

2 MobiSnap Overview

Relational database systems are widely used to store and process company-wide data. As a result, MobiSnap aims at developing a middle-ware infrastructure that allows access to relational database systems from mobile computers with a clear semantics in presence of all operational scenarios (from high to unavailable connectivity). This platform will isolate programmers from the problems related to mobility and disconnection, allowing them to easily develop new applications to mobile environments, focusing only in application-specific problems. MobiSnap will be based on SQL, thereby also providing a close integration to legacy information systems.

Our targeted environment consists in a group of mobile users that are expected to have access to information stored in the database server in any situation. For instance, a group of sellers that are visiting their prospective clients should have access to information about the products (description, prices, stock) they are selling. They should also be able to enter their customers orders, which are (later) transmitted to the supplier central server. In another example scenario, next generation mobile phone users should be able to manage their stock portfolio, and trade stocks, using their mobile phones. The stock and portfolio information is also stored in a central server managed by the broker.

Mobile users require access to subsets of all information that exists in the central

servers To this end, each mobile client caches the relevant information to be able to perform his work. In our system the pre-fetching policy will be based mainly on the combination of users profiles and data clustering [1].

Caching and update propagation algorithms will be based on the notion of database snapshot. Each database snapshot is composed by several table snapshots. Table snapshots include a subset of rows and columns of a given table, and are defined as the subset of table rows that match a certain condition. For instance, a given person would only need a snapshot related with the stocks he or she owns and the ones his broker suggests he or she should acquire.

As strict consistency of information is not required in most situations, mobile users may continue their work in disconnected mode using cached data (snapshots). For instance, sellers do not need to have up-to-date information about products to continue their work or stocks can be sold even when the exact current trading value is not known. However, as in some circumstances, decisions may be taken based on the weakly consistent data, MobiSnap provides a mechanism to express transaction validity based on the evaluation of preconditions and data integrity conditions. It also provides an integrated mechanism to send awareness information to users depending on real transaction processing outcome. This mechanism will be based on the definition of transactions in an extended subset of PL/SQL.

Transactions issued by mobile users will be logged and later propagated and reintegrated in the central database. These transactions may be applied to cached data or not, depending on users preferences. This mechanism also allows submission of transactions executing over data not present in local cache (as applications have knowledge on tables structure, transactions may be defined). Thus, complete operation is allowed in presence of any connectivity conditions.

Although weak consistency of snapshots is acceptable for several operations, strict consistency would be preferable. Therefore, the system should be responsible to guarantee that data divergence is kept below a given threshold. To this end, near to the database servers, a proxy of each mobile client is responsible to track all changes made to the data cached by each mobile computer. This proxy is responsible for evaluating data divergence in order to minimize risk associate with users activity.

Whenever data divergence exceeds a user-defined threshold, users are notified to perform data synchronization or at least to be warned that data divergence has reached some threshold. The combination of synchronous communication sessions with asynchronous notification mechanisms, as those presented by GSM, will enable a wide support for different connectivity degrees. For example, it is usual that in border areas, asynchronous SMS notifications are available although the quality of service is insufficient to establish synchronous connections.

The importance of data consistency for mobile users activity is diverse for different data items, and for the same data item, it may be diverse for different ranges of values. For instance, sellers should have precise information about products price. However, regarding available stock they only require exact values when supplies are running short. In general, the importance of each data item consistency is highly related with the risk

associated with missed opportunities and invalid transactions due to outdated data. The same is true for the stock portfolio example.

In MobiSnap we will develop a mechanism to express data items importance. The associated metrics will be used to determine when users should be notified about data updates and how urgent each notification is. These metrics will also be used to determine when clients should propagate mobile users updates to servers, in order to increase the probability of transactions success. We believe that the combination of the proposed mechanisms will create an infrastructure that will simplify the production of new mobile application when compared with the currently available tools.

3 Closing Remarks

In this abstract we have introduced the main aspects of MobiSnap design goals. Our strategy was to design a pragmatic and flexible platform that could support further experimentation on the database access policies that fit mobile environments. Although extensive research has been conducted on database replication and multi-database systems, we believe that the highly asymmetric scenario that characterizes mobile database access introduces new significant issues. Some of these issues are already predictable, and most of the known ones are accounted for in the MobiSnap design decisions, but we are confident that other issues will only be uncovered when developing a platform such as this.

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