

# Power-Efficient Caching Strategies for Mobile Environments

\*Sooyong Jeon, \*\*Sunho Lee, \*\*\*Dong-Ho Cho

Department of Electrical Engineering and Computer Science  
Korea Advanced Institute of Science and Technology (KAIST)

\*syjeon@comis.kaist.ac.kr, \*shlee@comis.kaist.ac.kr, \*\*\*dhcho@ee.kaist.ac.kr

## Abstract

In mobile environments, the caching of frequently accessed data in the battery-powered mobile terminals is a very attractive technique in terms of the power and bandwidth efficiency. The invalidation report (IR) based cache management scheme, one of the popular cache management schemes by its scalability, maintains the data consistency by using the IR indicating the update history of data. In this paper, we approach the IR-based cache management scheme in view of the power efficiency and propose the power-efficient cache management schemes. With the proposed schemes, redundant data request messages for the identical data decrease significantly. Simulation results show that the proposed schemes have a great effect on the power saving of mobile terminals and the uplink bandwidth saving compared with the conventional IR-based cache management scheme.

## 1. Introduction

Broadcast data transfer is a very efficient way of disseminating the data to massive users and is diversely applied to the traffic information system, stock information system, weather report system, etc. With unicast data transfer, the data is transferred separately to individual users that request the identical data, therefore it causes a scalability problem and a waste of the power and bandwidth. In [1][2], it is shown that broadcast data transfer is also a very efficient method of transmitting data to massive users in mobile environments, since the power and bandwidth are more critical factors in mobile environments. There were many studies performed on how the data can be efficiently transferred from the server to the clients in mobile environments [3]-[7].

In mobile environments, where the data is broadcasted, the caching of frequently accessed data in the client side is a very useful technique for improving the efficiency of the power and bandwidth. When using the caching technique, the data consistency between the data in the cache and that in the server must be ensured. Barbara and Imielinski provide the timestamp (TS) scheme that utilizes the invalidation report (IR) which is broadcasted periodically by the server [4]. In the TS scheme, the clients manage the cached data by using the IR which indicates the updated data ID list of past  $w$  IR intervals (with  $w$  being a fixed parameter). So, any client having been disconnected longer than  $w$  IR intervals has to discard every cached data even though it is valid. To solve this long disconnection problem, Jing et al. proposed the bit-sequence (BS) scheme that uses the IR organized as a set of binary bit sequences with a set of associated timestamps [8]. In the BS scheme, the IR contains the information about half of the recently updated data hierarchically and the clients discard every cached data only when half or more of cached data is invalidated. Although the clients can deal with the long disconnection in the BS scheme, the server has to broadcast heavier IR compared to the TS scheme. Wu et al. proposed the validation check scheme in which every client has to assess its cache validity after reconnection to solve the

long disconnection problem [9]. However, this approach requires more uplink bandwidth. In [10], Cao proposed the modified TS scheme to reduce the delay and to improve the low bandwidth utilization.

Although aforementioned studies have been made on improving the performance of IR-based cache management scheme, it still has a drawback in view of the power efficiency. In this paper, we address the problem of the conventional IR-based cache management scheme and propose power-efficient cache management schemes. With the proposed schemes, the information related to the requested data in the server is broadcasted several times during IR intervals and the clients behave intelligently using this information to request the data. As a result, the required power of clients and uplink bandwidth is saved by reducing the redundant data request messages for the identical data.

The rest of this paper is organized as follows: Section 2 introduces the conventional IR-based cache management scheme and addresses the problem of the conventional scheme. In section 3, we propose the power-efficient cache management schemes. We evaluate the performance of the proposed schemes in section 4 and finally, conclude in the last section.

## 2. IR-based cache management scheme

In a general broadcast data transfer system, the clients request the data on demand through the uplink channel and the server broadcasts the data requested by the clients. In this study, we assume that the data is updated only in the server and consider the most recent value consistency model which was used in [10]-[12]. In this model, the clients must always access the most recently updated data. Therefore, if the clients perform caching, the cached data in the client must be the most recently updated data.

In the IR-based cache management scheme, the server broadcasts the IR every  $L$  seconds to ensure the data consistency between the data in the cache and that in the server. The IR has the information about the current timestamp ( $T_i$ ) and