

A Comparative Study of Energy Efficient Air Indexing Techniques for Uniform Broadcasting

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ABSTRACT

Currently, wireless data broadcasting is a very popular data dissemination method for broadcasting public information to a large number of mobile devices at the same time. Access Latency and Tuning Time are the two main parameters to evaluate the performance of a indexing technique of data broadcasting system. Indexing can significantly reduce tuning time by switching clients to turn into doze mode while waiting for the desired data to arrive.

There are various indexing techniques for uniform data broadcasting over a channel. In this paper, we summarize the energy efficient problem and the possible solutions i.e. the indexing techniques. The popular indexing techniques are compared on the basis of two parameters and we suggest the best one.

Keywords

Energy efficient, Air indexing, data broadcasting, indexing techniques, hashing techniques, distributed indexing, Flexible Indexing.

1. INTRODUCTION

Mobile computing is one of the immersed issues in the recent trends of Information technology. The mobile user wants to access information while on the move. Recent advances in technology have provided portable computers with wireless interfaces that allow networked communication even while a user is moving [1]. In the near future, we can expect that millions of mobile users equipped with portable computers. They can retrieve information through the wireless networks anytime and anywhere.

Mobile computing is characterized by four constraints [1][2]:

1.1 Limited Resources

Usually, Mobile elements have limited computing power, lesser storage space and smaller display screen than stationary devices.

1.2 Connectivity is Highly Variable in Performance and Reliability

Some may offer reliable, high-bandwidth wireless connectivity to the mobile devices while others may only offer low-bandwidth connectivity. A mobile device may have to rely on a low-bandwidth wireless network also with some gaps in coverage of connectivity.

1.3 Finite Energy Source

While battery technology will undoubtedly improve over time, the need to be sensitive to power consumption will not diminish. Concern for power consumption must span many levels of hardware and software to be fully effective.

1.4 Mobility

A mobile computer's network address changes dynamically. Its current location affects configuration parameters as well as answers to user queries, and the communication path grows as it wanders away from a nearby server. Service handoff which enables continuous data access in different cells should be transparently.

These constraints are not artifacts of current technology, but are intrinsic to mobility. They complicate the design of mobile information systems and require us to rethink traditional approaches to information access

.In wireless environment, there are two fundamental modes to provide clients with information [1]:

1.5 Interactive/On-Demand

The client sends requests to the server through uplink and the server responds by sending the desired data to the clients.

1.6 Data Broadcasting

The server broadcasts data on a communication channel periodically. One or more clients just listen to the channel and wait for data coming. In practice, a mixture of the above two modes will be used. The most frequently accessed pieces of data will be broadcasted to the number of users. Since the cost of broadcasting does not depend on the number of data accessing users, this method scales well with the number of users.

For example, if the stock information about the stock's prices are to be broadcasted every minute, then it does not matter whether there are 100 users or 10,000 users, who are accessing the data, the average waiting time will be there.

The on-demand mode will be used for the less often requested data, because broadcasting these data periodically would be a waste of bandwidth. Even in the on-demand mode, it makes sense to batch requests for the same data and send the data once, rather than cater individually to each request [3]. An optimal method to decide which data items to broadcast and which ones to provide on-demand is described in [1].

Furthermore, it proposes an algorithm for optimal allocation of the network bandwidth between the broadcast data and the on-demand data. In addition, [1] addresses policies for interleaving on-demand data with broadcast data. Because data broadcast allows users to retrieve data simultaneously with a cost independent of the number of users, it becomes an attractive solution to compensate for the limited resources in the mobile environment. Current research on data broadcast can be roughly divided into three categories [4]:

1.7 Determining the Data for Broadcasting

The volume of broadcast data influences the access latency. Only most frequently accessed data items will be broadcast. How to dynamically broadcast the most frequently accessed data is the main problem.

A common technique is to drop a data item from the broadcast channel and re-estimate its access frequency from the on-demand data requests [5] [6] to make sure that the dropped data item is actually no more frequently.

1.8 Scheduling the Data Broadcasting

The data items to be broadcast may have different access frequency. The problem is how to arrange the broadcast data to minimize average response time for data request. The probabilistic and periodic broadcasting methods were studied in [1], [7] and [10] respectively. The issue of fault tolerance on the broadcast data was studied in [8], [9], [11], [12] and [13]. In [14], the broadcast is rearranged based on the structure proposed in [7] for supporting range queries.

1.9 Indexing the Broadcast Data

Building indexes on the broadcast data helps users to decide whether their desire data are in the broadcast channel or not and when they should become available for accessing the desired data. During the waiting for the data, the mobile devices can be switched into a power saving mode i.e. doze mode to save the energy of battery and switched to active mode when desired data is available.

The problem is how to mix the index with the data items such that access time, response time and energy conserving can be minimized. Indexing techniques were studied in [8], [9], [3], [15], [16] and [17].

2. BROADCAST AND INDEXING

If data is broadcast without any form of index, then the client will have to be tuned to the broadcast channel continuously until all the required record is found and then it is downloaded. On the average, the client has to be tuned to the channel for half the duration of the broadcast cycle.

This is unacceptable, as the mobile devices is equipped with a limited energy resource i.e. battery and the client remains in the active mode for a long time, thereby consuming precious battery resource.

We would rather provide a selective tuning ability, enabling the client to come into the active mode only when data of interest is being broadcast by providing a index information of the data. Selective tuning will require that the server, in addition to broadcasting the data, also broadcast a index that indicates the point of time when particular records are broadcast and available on the broadcast channel.

Clients will remain in the doze mode most of the time and tune in periodically to the broadcast channel.[1]

In data broadcasting, there will be competition between two parameters:

2.1 Access Time

The time elapsed from the moment a client wants a data to the time when required data is downloaded.

2.2 Tuning Time

The amount of time spent by a client listening to the channel. This will determine the power consumed by the client to retrieve the require data. To listen to the broadcast channel, mobile devices must tune in active mode, so the tuning time is also the time mobile devices in active mode. In a broadcast program with no indexes, both the access time and the tuning time will be $N/2$ in average where N is the cycle time of this broadcast program.

The data broadcasting can be of two types:

2.3 Uniform Broadcast

In uniform broadcasting, all data will be broadcast once in each broadcast cycle. Under this approach, all data will have the same average access time of a half of the length of a broadcast cycle.

2.4 Nonuniform Broadcast

In nonuniform broadcasting, some data which is very frequently accessed will be broadcasted more than once in a broadcast cycle. Such a nonuniform broadcast was shown to be superior in terms of average access time than uniform broadcast [7].

3. INDEXING SCHEMES FOR UNIFORM BROADCAST

There is various air indexing schemes for uniform broadcasting over a channel, which also provides energy efficient solutions. The popular indexing techniques are:

3.1 Hashing Scheme

This scheme is proposed in [1]. In this scheme, each bucket has two parts: the data part and the control part. The control part is the "invest" which helps guide searches to minimize the access time and tuning time both.

3.2 (1,m) Indexing

(1, m) indexing is an index allocation method in which the index is broadcast m times during the broadcast cycle [1]. The whole index is broadcast preceding every fraction of $(1/m)$ of broadcast cycle.

3.3 Distributed Indexing

To avoid longer access time in (1, m) indexing, distributed indexing was proposed in [2]. Distributed indexing is a technique in which index is partially replicated. This method is based on the observation that there is no need to replicate the entire index between successive data segments.

3.4 Signature Technique

Signature methods have been widely used for information retrieval. A signature of a data frame is a bit vector generated by first hashing the values in the data frame into bit strings and then superimposing them together. The signature technique

interleaves signatures with their associated data frames in data broadcasting [15].

3.5 Hybrid Indexing

Both the signature and the index tree techniques have advantages and disadvantages in one aspect or the other. For example, the index tree method is good for random data access, while the signature method is good for sequentially structured media such as broadcast channels [17].

3.6 FlexInd

A Flexible and Parameterizable Air-Indexing Scheme FlexInd is a hybrid indexing method that takes advantage of three separate air-indexing approaches, namely (a) no-indexing, (b) exponential indexing, and (c) flexible distributed indexing. [18]

4. COMPARASION

This section presents results of a study conducted to evaluate the performance of various indexing schemes. On the basis of two parameters, access latency and tuning time, we examined the following indexing schemes: (1) Hashing schemes (2) (1, m) indexing (3) Distributed indexing, (4) Signature Indexing (5) Hybrid Indexing (6) Flexible Indexing.

The access latency and tuning time metrics are measured in the unit of buckets. In each study the number of data items disseminated by the broadcast server amounts to 100,000. Similar to other researchers, we assume that the demand probability of data items follows a Zipf distribution [21] with the parameter set to 0.8,

it means that approximately 75% of all requests apply to 25% of the data items. A Zipf-factor of 1 is used as default. We assume an index element can be put into a packet and the size of a record is 32 packets default.

Table 4.1

Parameter items	Default value
ServerDBSize	10,000
NumPart	3
Relative frequency parameter (δ)	1
Zipf-factor (θ)	1
Index item size	1 (packet)
Data item size	32 (packets)

In different application, we may have different probability of data items to be broadcast. We conducted an experiment by varying the probability of data items with Zipf distribution from 0.1 to 1. Figure 4.1 and Figure 4.2 shows the result of this experiment.

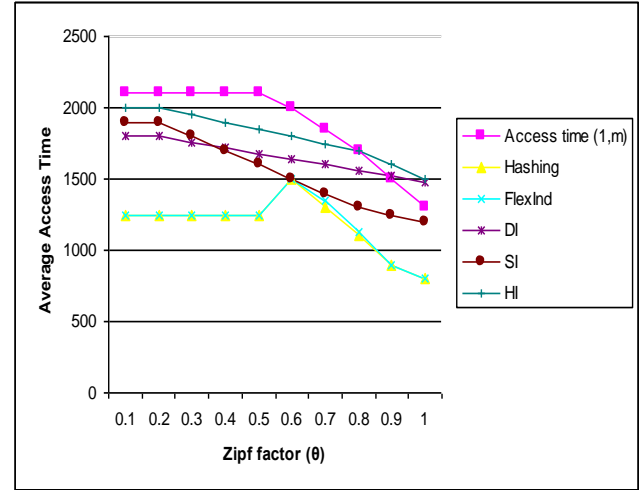


Fig 4.1 Average access time for different zipf factors

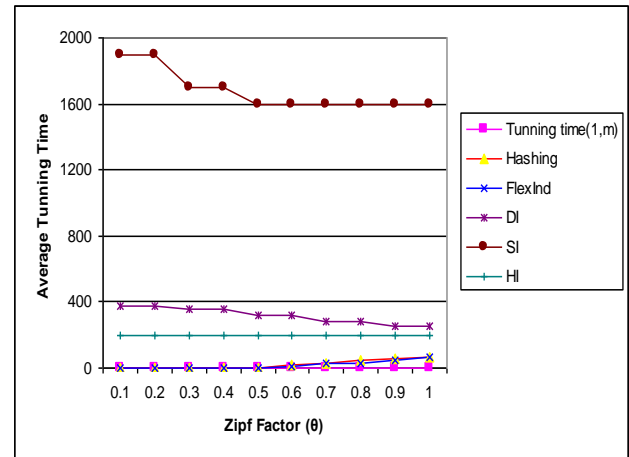


Fig 4.2 Average Tuning time for different zipf factors

5. CONCLUSION

Access time and tuning time are the two most critical issues in wireless data broadcast systems. Unfortunately, optimizing one of these two metrics always conflicts with optimizing the other one. To be able to meet different performance requirements of different applications, we need a flexible and tunable air-indexing scheme that is able to optimize the system performance with certain guarantees on either of the two performance metrics. In this paper, we analyzed the indexing schemes, how to optimize the access latency (tuning time) with a bounded tuning time (access time) by searching the optimal values of the tuning parameters of the schemes. Through extensive experiments, we demonstrated that:

First, The relative performance of the various schemes are analyzed with a variation of Zipf factor(θ) to the two parameters i.e. average access time and average tuning time. FlexInd achieves a much greater flexibility in trading-off between access latency and tuning time than state-of-the-art indexing schemes. Although the ExpInd indexing scheme also shows the similar characteristics as FlexInd but in the average tuning time FlexInd is slightly better than ExpInd.

Second, as θ increase, both the access time and tuning time decrease. This is expected since a higher θ value implies that the size of the most frequently accessed partition is smaller, and the number of clients accessing this partition increases.

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