Data in Your Space (DAYS)

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1. Introduction

We define the space as ``persistent data storage'', which conforms to essential database characteristics such as consistency, recoverability, and security. From the user point of view it allows information access, information modifications, and information storage without spatial and temporal constraints. Thus, a user can access necessary information, deposit important information for future use, communicate with other users, etc, without any restriction.
In this paper we present our approach for using the space as persistent data storage. Figure 1 illustrates our vision of information space. Every component, static or mobile, is connected with another component and any component can establish communication with other components anytime and can access, deposit, and manipulate desired data concurrently along with other activities. This can serve as global yellow pages and navigational system. Our objective is to provide necessary data and its modification capability to static (bank, lighthouse, etc.) as well as to mobile (human, airplane, ship, etc.) users through broadcast. Broadcast approach has been in use for sometime, however, its full potential has yet to be utilized. We argue that DAYS significantly enhances the scope of broadcast technology without creating mismatch with traditional approaches. We call our system DAYS. We visualize DAYS space through wired and wireless channels. The wireless connectivity manages the front-end (user level) data processing activities and the wired channels manage background activities such as database updates, recovery, concurrency control, etc.

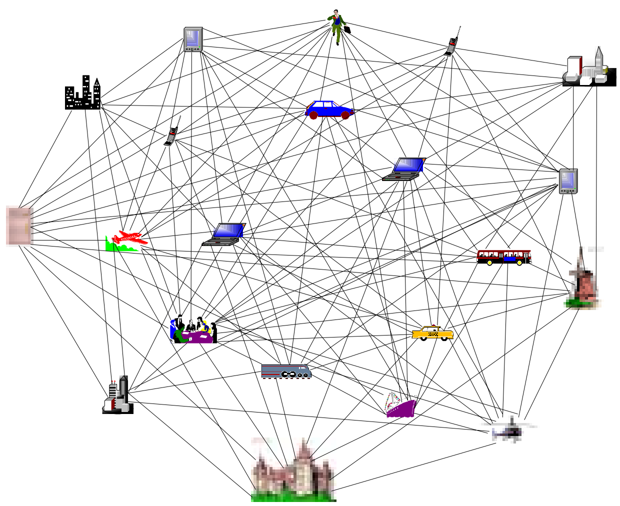

Figure 1: A fully connected information space

DAYS is mostly push based, however, it also deploys pull concept for certain types of activities. In conventional mobile systems based on PCS architecture, the essential component *base station* (BS) serves as the link between wired and wireless parts of the entire system. It is possible to migrate some of its services closer to users (mobile nodes) and some the switches. We have used this approach in developing DAYS architecture. Figure 2 shows how a conventional mobile system disseminates data to users. Figure 3 depicts a basic framework of DAYS. One of the main components of the system is the broadcast station, which is responsible for pushing data and also for deploying pull with the help of mobile clients.

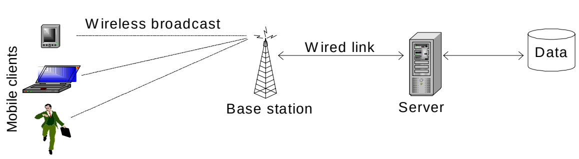

Figure 2: Conventional PCS broadcast

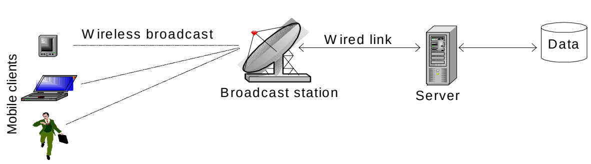

Figure 3: Our broadcast based system

The elimination of BS also helps us to skip the use and management of HLR and VLR and reduces the cost and overhead without introducing undesirable limitations in information management. One of the important aspects of DAYS is that the data storage is not bounded either in terms of space or geographic location. Mobile users read their desired data from the broadcast. We present two examples to illustrate the practicality of DAYS.

Example 1: American Automobile Association provides support services (tourbooks) to drivers in the United States. A perfect application of broadcast would be to broadcast tourbook information.

Example 2: A busy airport can broadcast flight schedule for users.

One can argue that this information can be obtained from the web site of the airline. This is possible but note that a user must have access to the web, the URL, and the mobile unit must have a browser installed. An approach might be to have changes made to Web data, which can be automatically used as the source for the broadcast. Thus, triggers associated with Web data would force changes to the broadcast data.

2. Motivation

The radio frequencies (RF) bandwidth used for wireless communication is quite narrow. It is, therefore, essential that these channels must be utilized efficiently. "Frequency reuse" is one of the ways for improving channel utilization. We propose to eliminate this restriction so that a mobile client can tune to any frequency from anywhere and download the desired data. We define the concept of ``dedicated" channels for developing DAYS. Under this scheme DAYS continuously broadcasts data on these channels and users can tune to the dedicated channel from anywhere and download the desired information. Thus, these dedicated channels serve as a persistent storage and also as communication routes to other processing nodes. We propose to design an effective and efficient technique to disseminate information through wireless channels. This cannot be achieved with traditional wireless system because

- In traditional architecture, an MU is completely dependent on its BS for interacting with the network. Thus, at all the time the MU must maintain a tightly coupled relationship with a BS.
- A BS controls the assignment and usage of channels by MUs.
- A MU must complete specific connection steps and register with a BS before it can be functional.

In our proposed system we assume that the mobile client is both more independent and intelligent in performing its wireless data access. This is accomplished with little increase in the assumption of available MU resources. Unlike the conventional approach where the MU and BS are tightly coupled, in our approach no such associations exist. Any mobile device can read the data broadcast by servers in the DAYS architecture. In our approach channels could be predefined to broadcast particular types of data. This is similar to the approach used for assignment of radio frequencies. Once a frequency range is assigned to a radio channel, that channel can have the range for an unlimited period. This technique should work well for usage of channels in a wireless data broadcast environments. Users can rely on the fact that certain channels have certain data. The actual data being broadcast need not be fixed, however a program of data to be broadcast should be known (just as is with TV and radio stations). For example, during afternoon and evening rush hours, traffic data could be used. During lunch time, restaurant information would be broadcast, and in the evening, hotel and entertainment information could be broadcast. The important thing to realize with this approach is that the channels are fully utilized. Data is continually broadcast. MUs tune to and read the data from the channels that they want and need. If MU clients wish to see data that is not being broadcast, requests for data can be implicitly or explicitly made through a fixed host coordinator, which is responsible for the programming of the content of broadcast data channels.

3. Problems to be solved

One of the main problems we address here is related to management of wireless channels, which includes (a) Channel Identification, (b) channel indexing, (c) assignment, and (d) broadcast management.

Channel Identification: It is necessary for a mobile unit to identify the right channel for tuning during its movement. For example, consider the situation that a mobile unit is tuned to a channel and downloading census data while moving. At some point the mobile unit may go out of the coverage area of the tuned channel, which will create discontinuity in the flow of data to mobile unit. If the census data is broadcasted on another channel, which can be reached by the mobile unit from its new position, then first it must identify the channel frequency. This problem is identical to the problem of finding a local radio station channel by a traveler when he/she wishes to listen to a local radio station at the time of renting an automobile in a new city or passing through a different broadcast region.

Channel Indexing: This approach aims to minimize the channel identification time. Instead of scanning all channels sequentially, MU will just scan the index to identify the right channel. This index could be provided in several ways. A general index can be created which is used by the MU to identify the correct frequency provided in several ways. One such approach would be to have one channel designated universally (or nationally) as an ``indexing channel". The MU would then first listen to this channel to find the correct frequency, then tune to this frequency. Note that this index channel can broadcast other data but will be know to all MUs as the index channel.

Channel Assignment: We propose to establish one to one relationship between the type of information to broadcast and a broadcast channel. For example, if there are ``X" number of channels available, then we identify which one would broadcast weather information, which one would broadcast census data, and so on. We may create the association randomly or depending upon channels bandwidth (frequency range). For example, we may select a larger bandwidth channel to broadcast census data (large volume data) and narrower band channel to broadcast restaurant data (small volume data). Our aim here is to optimize the use of available channels of that locality.

Broadcast Contents: The contents of these broadcast channels will change depending upon the requirements of the users, which may be dependent on the time of the day, for example, weather and news in the morning, entertainment information in the evening, etc. For achieving the highest data hit rate and highest channel utilization a garbage collection scheme and also a data replacement scheme are necessary. We plan to use (a) static and (b) dynamic approaches. In static approach a user will notify the broadcast server its present and future data pull and approximate duration for their use. The server will continue to broadcast the static data set for the defined period. In the dynamic approach the data requirements will be identified using (a) Residence latency (RL) and Expected Departure Time (EDT).

Garbage Collection: It is quite possible that some data on some channels may get ``stale". We define stale as data that has not been used for some time or data which has been updated at the IS. We wish to be able to identify stale data and remove from the broadcast.

Migrating Data: Migrating data is data, which is associated with a client(s) and follows her/his movement. A MU may move around in the channel space while still downloading information from the tuned channel. It is possible that the MU can go out of the channel reachability and it may not complete the download. We propose to develop a scheme to eliminate discontinuity in a download. Our approach will make sure that the MU can continue to download the same data from the next channel to which it tunes. This gives the impression that the data being downloaded moves with the MU. A major problem associated with broadcast data is that ``passive" users have no way to explicitly indicate what they wish to read. Even though our DAYS architecture may be coordinated with a traditional wireless architecture we will investigate ways to solve this problem without explicit user requests for data. We call these techniques implicit requests. An implicit request is a technique, which can be used to identify the user data requirements. In addition, these implicit requests will help to determine what data is stale and to help to ensure that the needed data is available regardless of the user MU movement. To manage migrating data we will evaluate three approaches:

User Profile: Clients often travel over the same routes with similar data needs. For example commuters use traffic information and truck drivers may have predefined routes. These profiles can be identified at the time that users register with the DAYS coordinator as a new user or may updated by a subsequent visit to the DAYS Web page.

Cookies: We propose that data and movement pattern information be kept in cookies at the MU (if space is available). Any time the client then accesses the DAYS Web page, this information can be uploaded automatically to update the user profile information.

Data Indexing: We assume that data, which is broadcasted is grouped into cycles. Each cycle consists of a fixed set of indexed data. The data contains the cycle number, index, and list of data items, which are continually broadcast throughout the life of that cycle. A consecutive set of cycles is referred to as a window. Each data item that is being broadcasted has a span window, which is the window size through which that data item is to be broadcasted. If the data item is modified at the IS during this time period, the new data item value is to be broadcast for another time frame of this span window size. Think of this window as indicating the time period during which the item will be broadcasted after it is modified. Data to be broadcasted is obtained by the DAYS Coordinator from the IS using a conventional read transaction. This data (including index and cycle number) is sent to the BRS where it is broadcasted.

4. Conclusions

We have proposed a system called DAYS, which creates a global information space from where consumers of information access and modify the desired data free from temporal and spatial constraints. DAYS implements push and pull concepts for creating the global information space and allows clients to surf freely.