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Implementation of Framework for Efficient and Scalable Disaster Response Services

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Abstract

The global warming by greenhouse gases causes climate change and disasters such as earthquakes and tsunamis frequently, leading to great damage. It is important to build efficient and scalable disaster response services to minimize the damage. Existing disaster warning service by the mobile text is limited by the scalability and the data size to be delivered. In this paper, we propose a framework for disaster response services that is efficient and flexible by allowing to adopt various indexing schemes and scalable by supporting any number of clients in disaster situations anytime and anywhere. Also, the framework by wireless data broadcast can be free from the limitation of the size of data to be delivered. We design and implement the proposed framework and evaluate the framework. For the evaluation, we simulate the implemented framework by adopting various indexing schemes like HCI, DSI and TTSI, and by comparing the access times of the clients. Through the evaluation, we show that the proposed framework can provide efficient and scalable and flexible disaster response services.

Keywords: *Disaster Response System, Framework, Scalability, Flexibility*

1. INTRODUCTION

In recent years, global warming by greenhouse gases causes climate change and disasters such as earthquakes and tsunamis frequently, leading to great damage. In order to minimize damage in these sudden disaster situations, it is very important to build a disaster prediction technology that can accurately predict disasters as well as disaster response system that can let a great number of people prepare the disaster [1-3].

It is critical that the disaster response system can support any number of people at anytime and anywhere. The response system based on mobile text services can be limited in the aspect of the number of people to be supported and the size of data to be delivered. However, wireless data broadcast system is effective to the disaster response system because it accommodates any number of clients [4]. The system pushes data items onto the wireless channel then the clients access the channel and download their desired data items. Thus, the system can handle any number of clients anytime and anywhere.

Wireless data broadcast system adopts index information in order to allow the clients to search efficiently for their desire data items on the channel [5, 6]. The index information holds the broadcasting time of each data item on the channel. The broadcast server disseminates index information as well as data items on the channel. Therefore, the client obtains the broadcasting time for items after accessing the index on the channel. The indexing schemes using location information like HCI, DSI and TTSI can be adopted for

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disaster response services by wireless data broadcast [7-9].

In this paper, we design and implement a framework using wireless spatial data broadcasting techniques to construct an efficient disaster response service system. The framework to be designed and implemented is efficient and flexible because it can adopt various indexing scheme for the disaster data. Also, the framework is scalable that it can support any number of clients. This scalable characteristic is most important for the effective disaster response services.

This paper is structured as follows. In Section 2, as a related study, we review a methodology for searching for data items in a wireless channel and the index schemes for broadcasting. Section 3 shows the design of the proposed framework for disaster response services. In Section 4, we implement the broadcast server and client using the designed framework and evaluate the performance of the client by applying the indexing schemes HCI, DSI and TTSI. Finally, the conclusion is made in Section 5.

2. RELATED WORKS

2.1 Query Processing using Wireless Data Broadcast

In the wireless data broadcasting system, the clients process their queries, following the procedure of downloading the index from the wireless channel, searching for data broadcasting time, and downloading data from the channel. In the process of downloading the index, the clients tune in to a wireless channel and then downloads it at the index broadcasting time that is included in each data bucket. The clients check the broadcasting time of the desired data using in the index. The clients change to an energy saving mode until the data broadcasting time, then switch to an active mode at the broadcasting time and download desired data by listening to the channel, and complete the query processing.

2.2 Index for Selective Data Downloading

An index in a wireless data broadcasting system enables a client to selectively download desired data from a wireless channel, thereby enables energy-efficient query processing. Indexes can be divided into tree-based indexes and table-based indexes. HCI (Hilbert Curve Index) is a tree-based index that keeps the location information of spatial data using the Hilbert curve [7]. DSI (Distributed Spatial Index) is also an index using the Hilbert curve, and unlike HCI, it is a table-based distributed air index [8]. TTSI (Two-Tier Spatial Index) is an index in which the data space is divided by grid of two-tier and it is formed for each cell [9]. Unlike HCI and DSI, TTSI uses the actual location of spatial data, enabling energy-efficient query processing with short tuning time.

3. FRAMEWORK DESIGN FOR DISATER RESPONSE SERVICE

3.1 Design of Broadcasting Server

The broadcasting server for a disaster response service is designed to have the structure shown in Figure 1.

- Broadcast Manager: It manages entire modules in the server, receiving the scheduled disaster data for broadcasting from the channel configurer, and delivering the data to the transmitter to broadcast.
- Channel Configurer: It configures the channel by arranging alternately disaster data from the data scheduler and index from the index former.
- Data Scheduler: It arranges the disaster data received from Disaster DB in order to be broadcast on the wireless channel.
- Index Former: It generates an index using the specified method for disaster data received from the disaster DB. For the index, it adopts spatial index schemes for disaster data based on the location.

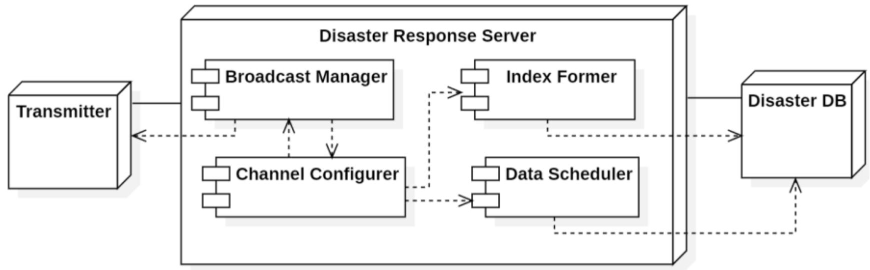


Figure 1. The structure of Broadcasting Server

3.2 Sequence of Broadcasting Disaster Data

The procedure for the server to broadcast disaster data follows the process shown in Figure 2.

1, 2: Broadcast manager requests for organizing the channel with disaster data items and the index for them to the channel configurer. Then channel configurer requests for scheduling the data to the data scheduler.

3, 4: Data scheduler requests for disaster data to be broadcast to disaster DB and receives the data.

5, 6: Data scheduler arranges the data in order to be broadcast and return them to channel configurer.

7, 8, 9, 10: Channel configurer requests for generating the index for the disaster data. Then the index former generates the index using the location information of the data from disaster DB and return the index to the channnel configurer.

11, 12: Channel configurer configures the broadcast channel by allocating the disaster data and the index alternatively and return to the broadcast manager for broadcasting.

13, 14: Broadcast manager sends the organized channel with data and the index to the transmitter and then transmitter broadcasts the organized channel.

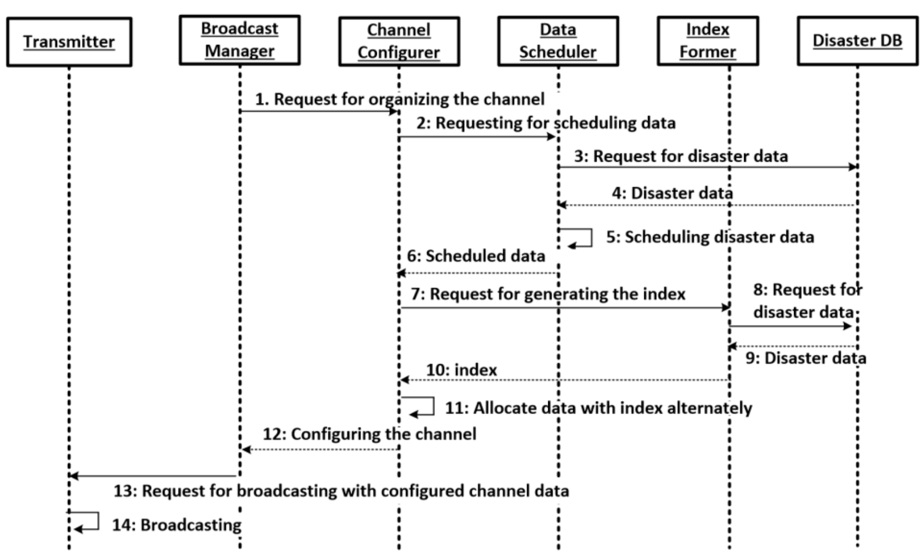


Figure 2. The Sequence Diagram for Broadcasting

3.3 Design of Client and Data Search

The client in the framework for disaster response service is consist of Disaster Processing Manager, Index Extractor and Tuner.

- Disaster Processing Manager: It manages each module in the client and makes the answer to the query of disasters.
- Index Extractor: It extracts the broadcasting time of the disaster data of client's current location from the downloaded index.
- Tuner: It listens to the wireless broadcast channel and download the index and disaster data from the channel.

The client follows the process shown in Figure 5 to search for disaster data and download them from the wireless channel.

1, 2: The user requests for disaster information. Then, the disaster processing manager requests for broadcasting time for the disaster data of current location.

3, 4, 5: Index extractor requests for the index to the tuner and then the tuner listens to the channel and download it and return the index to the index extractor.

6, 7: Index extractor filters out the broadcasting time for the disaster data of current location and returns the time to the disaster processing manager.

8: Disaster processing manager requests that the tuner downloads the data at the broadcasting time.

9, 10: Tuner listens to the channel and downloads the data from the channel at the time and returns the data to the disaster processing manager.

11: Disaster processing manager returns the disaster data to the user in order by displaying the information.

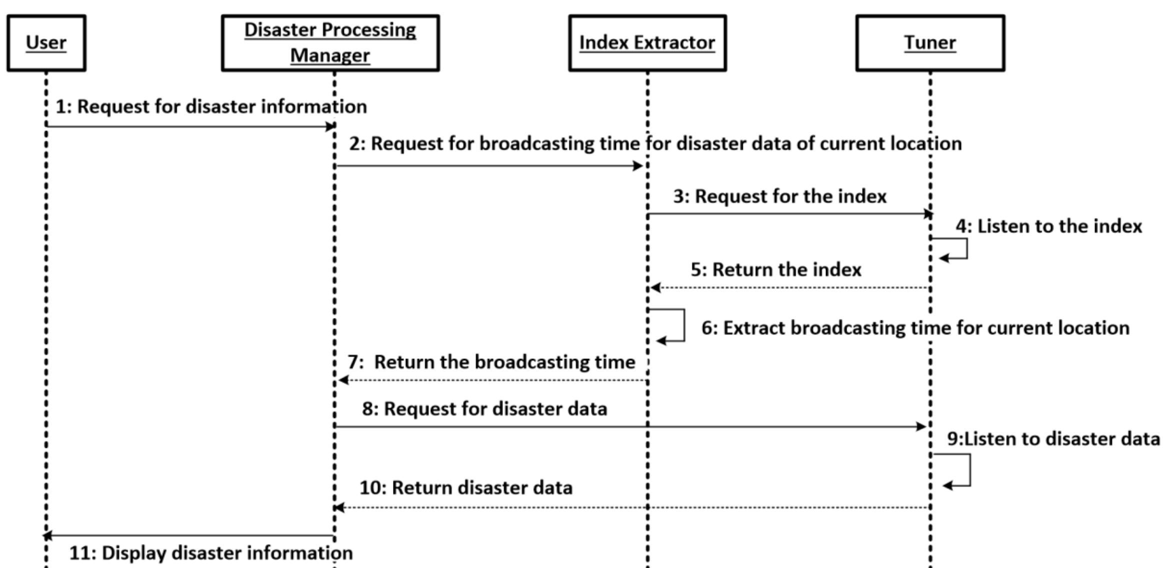


Figure 3. The Sequence Diagram for Searching for Disaster Data

4. IMPLEMENTATION AND EXPERIMENTS

We implement a framework for the disaster response service using the designed server and the client. In the framework, we have implemented the broadcast server, wireless channel, and the client using SimJave, a discrete time scheduler based on Java as shown in Figure 4 [10]. Using the implemented framework, we simulated the disaster response service that supports any number of clients in a disaster situation.

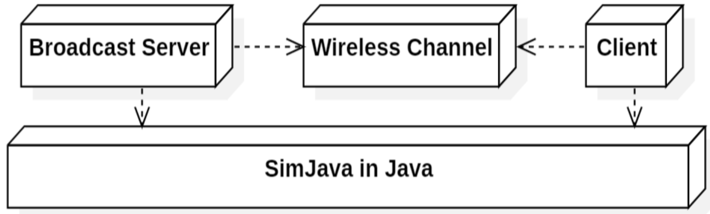
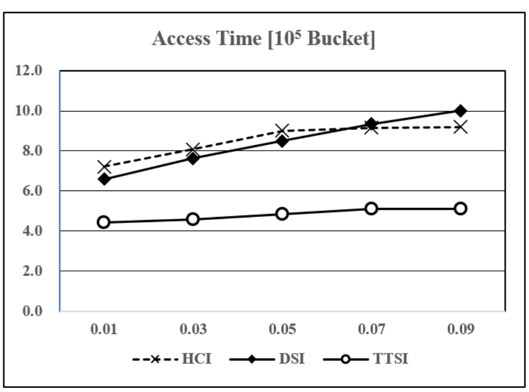


Figure 4. The Sequence Diagram for Searching for Disaster Data

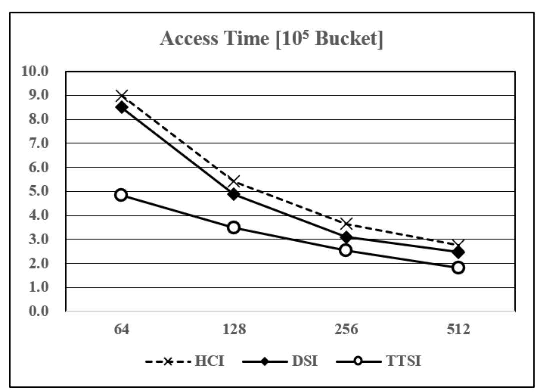
For the simulation, we use earthquake data as the disaster data provided from US Geological Survey in [11]. The data consists of 20000 cases of earthquake. For indexing the earthquake data, we adopt three index schemes, HCI and DSI using Hilbert Curve and TTSI using grid partition of data space. In order to evaluate the performance of the framework, we compare the access time as the performance matric for the three indexing schemes.

Figure 5(a) shows the access time by query size that is the region centered at the client current location. TTSI needs shorter access time than HCI and DSI. This results from that HCI and DSI force the client to access more data item because they use Hilbert Curve rather than real location.

Figure 5(b) shows the access time by the bucket size. Bucket is the logical unit for delivering the data like packet in networks. Varying the size of the bucket from 64 to 512 bytes, the access time of TTSI is shorter than those of HCI and DSI. That means TTSI is more effective than the others in the aspect supporting the client to access disaster data.



(a) Access Time by Query Size



(b) Access Time by Bucket Size

Figure 5. Comparison of the access time

As such, the proposed framework is so open and flexible that it adopts various indexing techniques and data scheduling techniques. The simulation results depict that the implemented framework efficiently delivers disaster data to large-scale clients using a wireless data broadcasting system.

5. CONCLUSION

In this paper, we designed and implemented the framework for efficient and scalable and flexible disaster response services. The framework consists of the broadcasting server, wireless channel, and the client. The framework is scalable for supporting any number of clients to deliver disaster data. It results from being designed on the wireless data broadcast. The framework enables to build flexible disaster response services because it can adopt various type of indexing schemes. To show the effectiveness of the framework, we have simulated the framework using real earthquake data items from US Geological Survey and have compared the access times by three indexing schemes, DSI, HCI and TTSI. The proposed framework for disaster response services can be applied to various disaster situation efficiently. Thus, the proposed framework is structured in the open and flexible way so that it is possible to adopt various indexes and data scheduling schemes. The simulation results with the testbed implented with the proposed framework show that it enables to deliver efficiently disaster data to large-scale clients in the wireless data broadcasting environments.

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