A Simply Implementable Architecture for Broadcast Communication Environments

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Abstract. With the recent increasing attention to the Internet of Things (IoT) devices and cyber-physical systems, highly useful information has been extracted from large amounts of data. There are various situations where data about highly useful information is shared by a large number of user clients, such as distributing traffic information to smart cars and distributing disaster information to smartphones in disaster-affected areas. In such a situation, by adequately distributing the shared data to a large number of user clients at once, the distribution server can deliver the data faster than the case of delivering the data to each client. However, in the conventional computing environment, distributing the data to each client is the basic (primary communication method), and there is a fundamental problem that the communication overhead associated with broadcast delivery increases. Therefore, in this study, we focus on the computational environment based on broadcast distribution. In particular, we propose a computational environment based on broadcast distribution via radio broadcasting and discuss its effectiveness.

1 Introduction

The attention to the super-smart society is increasing, and the number of user clients connected to the Internet, such as smartphones and smart cars, is increasing rapidly. On the other hand, with the recent increasing attention to the Internet of Things (IoT) devices and cyber-physical systems, a large amount of data has been generated continuously from various things.

By analyzing these large amounts of data, we can extract highly useful information. For example, the following applications can be considered.

- A super-smart society provides the location (traffic information) of other cars and pedestrians. While driving a smart car, it displays real-time surrounding traffic information. Drivers who learn that there are many people in the scheduled drive route change to a route with fewer people to avoid unexpected accidents.
- In the future, rescue robots will play an active role. Immediately after an earthquake, the robot requests relevant data to confirm the disaster information. Even if many robots frequently check, they can obtain the data immediately.

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When the above application is implemented with existing technology, there is a problem that the notification takes time in the situation where a large amount of data occurs, and the response takes time in the situation where there are a lot of data requests.

As mentioned above, in the case of data shared by a large number of user clients, it can be delivered at high speed by properly delivering it to a large number of user clients at once. However, in the conventional computing environment, individual distribution is the basic (primary communication method), and there is a problem that the communication overhead associated with simultaneous delivery increases. Although there is the broadcast-type distribution over the Internet such as IP multicast and IP broadcast, broadcast storms where data is reciprocating between communication devices are likely to occur, and most use is prohibited.

Therefore, in this research, we focus on the calculation environment based on simultaneous distribution, and model and propose a computational environment based on the simultaneous distribution (broadcast-type distribution) via radio broadcasting. In radio broadcasting, the processing load associated with simultaneous distribution does not depend on the number of destinations, and data can be transmitted together to multiple user clients within the radio wave reach range. In this paper, we discuss the effectiveness of the proposed computational environment.

2 Related Work

Some research and development of broadcast-type distribution have been carried out.

The Broadcast Computing Research Group of the Information Processing Society advocates computing itself using broadcast-type distribution. However, it has not been able to propose a specific computing environment, as shown later ([1]).

Hironaka et al. are researching and developing a hybrid cast system that distributes access destinations via radio broadcasts and downloads and displays the home page of the destination distributed over the Internet ([2]). However, it is not possible to broadcast data according to the user's situation.

The authors propose how to create a broadcast schedule when users use multiple data [3].

However, only predetermined data with a fixed broadcast schedule can be broadcast. Performance measurement, such as the time it takes to complete the delivery in the case of distributing the data used by multiple computers at once, is performed in [4]. It is assumed that broadcast-type distribution via the Internet is assumed rather than radio broadcasting. However, it can also be used as a reference in this study to confirm the effectiveness of broadcast-type distribution.

3 Modeling

3.1 Assumed System

Figure 1 shows a model of a computing environment based on broadcast-type distribution. The user client is connected to the Internet, and the broadcasting facility can receive the data distributed (broadcasted) all at once by radio wave broadcasting. The

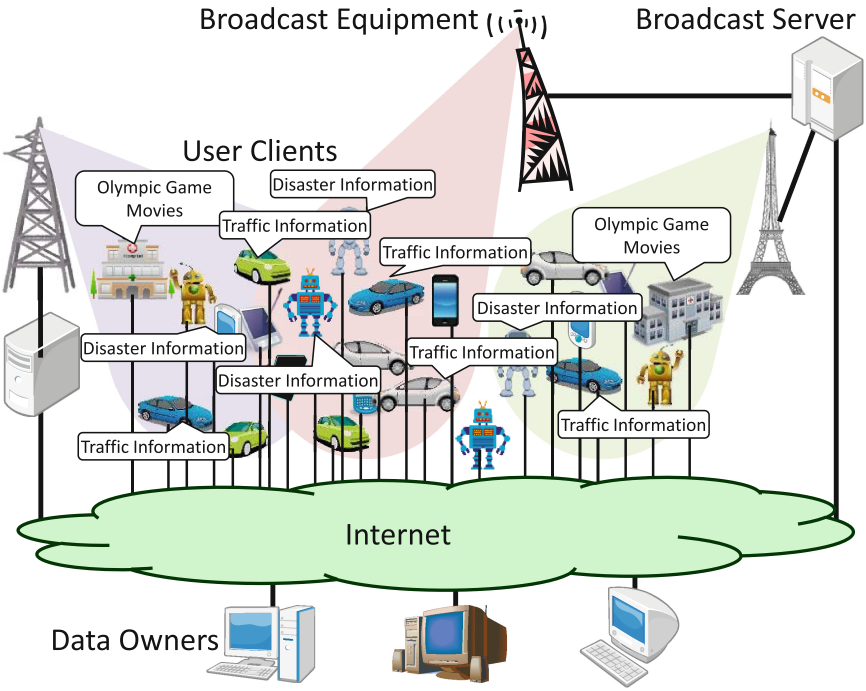

Fig. 1. A broadcast and communication environment

data received by the broadcast is automatically stored in the receiving buffer of the user client. If there is missing data to be used, the user client sends a reception request to the data holding terminal. The data holding terminal transmits the data to be held over the Internet or broadcasts it via radio wave broadcast. We do not broadcast all the data all the time. When broadcasting, the data holding terminal transmits data and broadcast range (user client using broadcast data) to the broadcast server. The broadcast server manages several broadcasting facilities, and data can be broadcast using each broadcasting facility. Data retention terminals and user clients can obtain the radio wave reaches and the broadcast bandwidth by querying the broadcast server. For example, a smart car is a user client, Traffic information data server is a data holding terminal, the server of the telecommunications company is a broadcast server, and a 5G base station has a broadcasting facility.

3.2 Application Example

We show an example that broadcast-type distribution can be processed faster than sending data over the Internet. In the heavy rain disaster in the Kanto region on June 24, 2014, there were 11904 accesses to the website. The amount of data on the relevant homepage is 860 K bytes, and a total of 10 Gb of data is transmitted. If the effective communication speed of the server of the homepage is 100 Mbps, it will take 1 min and 20 s to

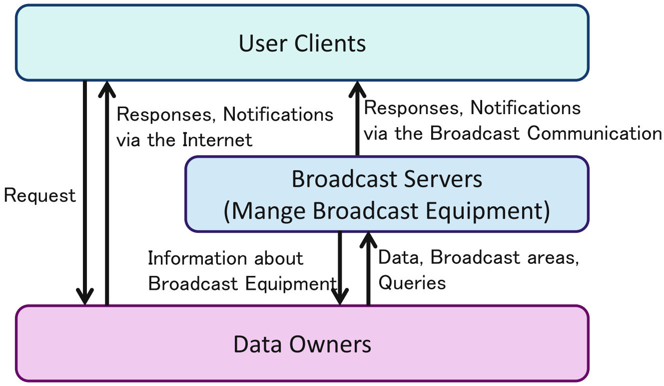

Fig. 2. A data flow diagram for our proposed broadcast communication environments

send the data of the homepage. On the other hand, the communication speed of terrestrial digital television broadcasting is 23 Mbps (all 13 segments) by ISDB-T method. Although the broadcast range varies depending on the radio tower, Tokyo Skytree covers 14,000 households in the Kanto region. The time it takes to send the homepage data to the user client in the Kanto region is 0.3 s. It can be seen that it can be significantly shortened even if it is compared only by the time it takes to send data simply.

4 Evaluation

Many users recently enjoy videos provides by video-on-demand services such as YouTube or Hulu. This means that one of the applications for distributing the data to many clients is video distribution. In this section, we evaluate our proposed environments under the situation that the server distributes videos.

5 Evaluation Setting

For the video distribution, the video data are generally divided into some segments and are broadcast according to the created broadcast schedule. There are some methods to create a broadcast schedule. The main drawbacks of the video distribution are the waiting time and the interruption time. The waiting time is from the time that each client request receiving the broadcast data to the time that the client starts playing the data. The interruption time is the time elapsed while the video playback is interrupted.

To reduce the waiting time and the interruption time, the broadcast schedule is created in order that the preceding segments are broadcast frequently. Because the chance to receive the preceding segments increases, the possibility that the clients can receive the segments before playing them increases. Thus, the waiting time and the interruption time are reduced.

In this evaluation, we compare three methods under the broadcast communication environments. The first one is the sequential method in that the server broadcasts segments from the beginning to the end sequentially. When the server finishes broadcasting

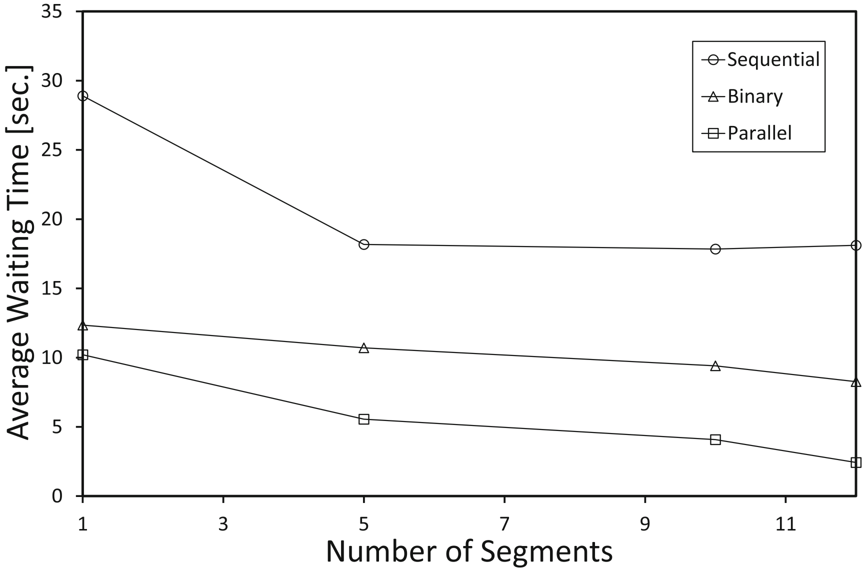

Fig. 3. Average waiting time and the number of segments

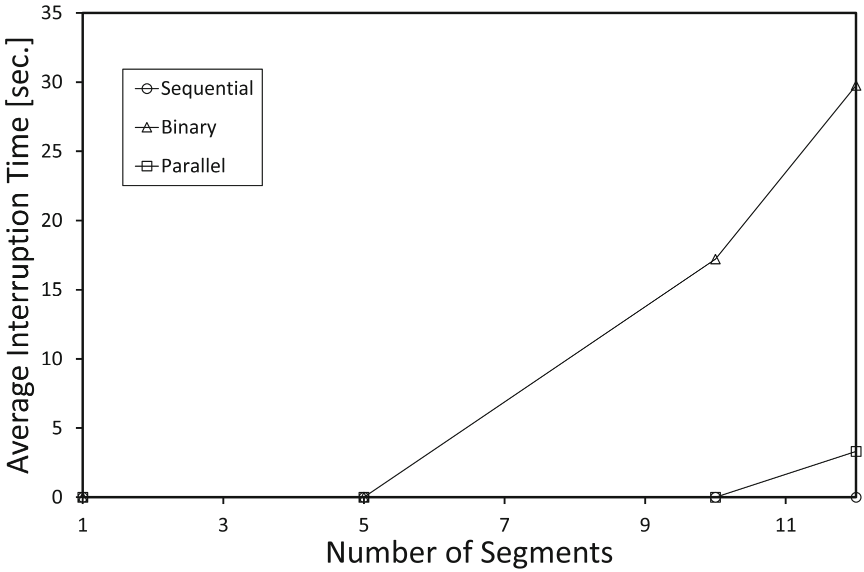

Fig. 4. Average interruption time and the number of segments

the final segment, it starts broadcasting the first segment again and keeps broadcasting segments cyclically. This method is the most simple and the conventional method. The next one is the binary method. In this method, the first half of the video data is broadcast several times, and after that, the last half of the video data is broadcast once. Since the segments included in the first half are broadcast more frequently than the segments included in the last half, the waiting time and the interruption time can be reduced. The last one is the parallel method in that the server creates some logical broadcast channels and broadcasts segments cyclically in each logical broadcast channel. By dividing the video data so that the broadcasting time for the preceding segment becomes shorter than others, the frequency that the preceding segments are broadcast increases, and the times can be reduced.

6 Evaluation Results

Figure 3 shows the average waiting time under our proposed broadcast communication environments. The duration of the video data is 1 [min.], and the time needed to broadcast the data is 5 [sec.]. The horizontal axis is the number of segments. For the case of the binary method, the horizontal axis indicates the times to broadcast the first half of the video data. For the case of the parallel method, the number of the logical channels is the same as the number of the segments. The vertical axis is the average waiting time until starting playing the video data from the time to request receiving the data.

From this result, we can see that the average waiting time decreases as the number of segments increases because the chance to receive the first segments increases. However, when the number of segments is excessively large, the interruption time arises, as shown in Fig. 4. The horizontal axis of the figure is the same as Fig. 3. The vertical axis of the figure is the average interruption time. Under the sequential method, the interruption time does not occur because the server broadcasts the segments sequentially. Under the binary method, the interruption time occurs when the number of segments is larger than 5. Under the parallel method, the interruption time occurs when the number of segments is larger than 10. The reason why the number of the segments that the interruption time occurs is larger than that for the binary method is that the server broadcasts segments in parallel. Since the intervals that each segment is broadcast are shorter than that for the binary method, the number of the segments that the interruption time occurs becomes large.

7 Discussion

7.1 Designation of Broadcast Area

In the proposed computing environment, other data can be broadcast according to the broadcast range. They can be delivered at high speed by broadcasting only from the broadcasting facility where the geographic range where the user client requesting the data and the user client of the notification destination exists are included in the radio wave reach range. As one of the methods of this realization, the data holding terminal first recognizes the broadcasting equipment that the geographic target range is included in the radio wave reach range, and transmits the identifier of the data to be broadcast to the broadcast server which manages the broadcasting equipment and the broadcasting equipment to be used. Next, the broadcast server broadcasts the data and the geographic target range using the specified broadcasting facility. When broadcasting, we determine the timing (broadcasting equipment schedule) in cooperation with other broadcast servers in consideration of multiple broadcasting facilities overlapping radio frequency reach and data waiting for it to be broadcast. Finally, the user client stores the received data when its position is within the geographic target range (Fig. 2).

8 How to Decide Broadcast Data

When the Internet's communication bandwidth is large, it may be faster to send over the Internet than to broadcast. Notification and response time can be shortened by broadcasting only when it is faster to broadcast. Therefore, the data holding terminal determines the delivery method, which can respond at high speed by comparing the transmission via the Internet and the delivery via the radio wave broadcast, taking into account the user client's location, communication speed, and broadcasting band. When sending data according to the request of the user client, the number of requests is also taken into account. Basically, the number of requests is large, the communication bandwidth is small, but the larger the broadcast bandwidth, the faster it is possible to respond at high speed when it is delivered via radio wave broadcast. However, it is necessary to transmit data to broadcast to the broadcast server, so if these fluctuate significantly over time, it may be faster to send over the Internet.

9 Conclusion

In this study, we proposed a computational environment based on broadcast-type distribution and modeled and discussed it. In the future, we plan to devise details of effective processing and communication methods.

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