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CONCEPTUAL OBJECT GROUPING FOR USER-CENTRIC STREAMING MEDIA SERVICE IN WIRELESS MULTIMEDIA SERVICE ZONES

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Abstract. *This paper proposes a new conceptual object grouping method for user-centric streaming media services in wireless multimedia service zones with fuzzy filtering. The proposed method can be used to automatically compose similarity relations between the objects by fuzzy relation to conceptual objects extracted from the client's request of wireless multimedia service domains. These conceptual objects are grouped to improve throughput and quality of service (QoS), and fuzzy filtering is used to decide on a similarity relation, for which μ-cut, fuzzy similarity (FS), and direct similarity relation (DSR) are applied. These techniques group related conceptual objects easily. In order to show the performance of the proposed method, about 5,000 conceptual objects were simulated. The simulation was conducted using a grouping method, a non-grouping method, and category-based method. The results show that the proposed method provides better performance than the non-grouping method and category-based method.*
Keywords: User-centric multimedia, Fuzzy filtering, Similarity relation, FS, DSR

1. **Introduction.** In recent years, several methods have been proposed to manage and service the huge variety of media information in wireless multimedia service zones. However, existing methods have some difficulties in user-centric streaming media services, since they are based on probability theory [1] and conceptual distance [2]. In the worst case, the desired service is not provided.

This paper proposes a new conceptual object grouping method based on μ-cut, FS, and direct similarity relation (DSR) for user-centric streaming media service, which automatically constitutes incremental multimedia service information. The proposed method can be used to automatically compose conceptual objects based on fuzzy filtering to maximize service utilization and throughput. The currently available conceptual grouping methods deal with the inference concept, not composing conceptual objects. The proposed method uses fuzzy filtering based on μ-cut to constitute a group. Conceptual object grouping is an efficient technique that assures the streaming throughput, service response, and cache hit rate. The proposed conceptual object grouping is composed of groups of conceptual objects that are semantically related to other conceptual objects, and it derives from a query extracted from a client's request [3-5]. In other words, if requested media object is derived as a specific query, conceptual objects extract the properties for grouping.

Existing methods have advanced capabilities, but they are limited in that the similarity relation between conceptual objects must be known [6-8]. The proposed method has merits of not only being able to maintain the semantic similarity relation between conceptual objects semantically, but also to compose conceptual objects hierarchically by using fuzzy filtering.

Efficient streaming media service requires functions such as streaming resources management for the continuous flow of media data, channel management for the minimization of the average latency time of data for transmission, data storage management to efficiently manage limited storage, and the minimization of network bandwidth and access latency [9,10].

A proxy caching mechanism satisfies these requirements, and has been proposed for wireless mobile networks for the streaming of user-centric media objects [11-13]. This mechanism streams media objects continuously without the access of clients to the server using data blocks in the proxy server. For the efficient streaming media service in wireless multimedia service zones, however, a caching system should consider the minimization of jitter latency, congestion control, and transmission hit rate.

A segment-based proxy caching method has been proposed to solve the problems, but has problems with streaming delay during classification, since media objects are randomly cached for streaming [14,15].

A category-based method groups conceptual objects by considering the similar media object that belongs to the same category [1,5]. Grouping methods have mainly been implemented using probability methods and conceptual distance, which are used to group and combine things that are nearest after measuring the distance between conceptual objects. This paper proposes a new conceptual object grouping method to service relevant objects, and to efficiently provide information needed by a user in an established system.

The proposed method can shorten delay time and service time, elevate the capacity of a system, and maximize its throughput. The proposed method can also help make the system more user-friendly, establish relevant information, and stream information quickly.

This paper is organized as follows. Section 2 describes related works. Section 3 describes the proposed conceptual object grouping mechanism. Section 4 describes the simulation result, after which a conclusion is presented.

2. Related Works.

Generally, users in an excellent multimedia service zone may enjoy a high quality service while users with a poor service zone may not. However, most wireless multimedia service zones perform services with the bit rate unequal to the bandwidth for streaming media service.

Typical streaming media service mechanisms neither consider conceptual grouping by fuzzy similarity and direct similarity relation of media objects nor perform user-centric streaming media services [9,17].

Miao and Ortega [16] proposed a selective caching mechanism to improve playback quality. This is an intermediate frame selection mechanism that caches service frames according to the transmission rate. This mechanism, however, has the problem that it cannot cache service frames directly after the initial segment.

Cardeli et al. [17] proposed a hierarchical caching structure for the streaming media service in the proxy system. This mechanism distributes streaming media objects on hierarchical paths. This mechanism is efficient in reducing the service load, while it has the problem of high streaming cost due to network latency.

Chang and Chen [18] proposed a grouping mechanism using object relation graph (ORG). This mechanism has the difficult problem of the streaming media service for clients with different service environments.

Patil and Dhage [19] proposed the priority-based congestion control protocol (PCCP) to enhance the streaming media service in wireless channel. This mechanism decides the sequence of its node to reflect the importance of the streaming node. Each streaming node is assigned a priority based on the amount of traffic originating at it and also the amount of traffic it is forwarding. The priority-based congestion control protocol performs streaming service using a parameter referred to as the congestion degree, which is defined as the ratio between the mean packet service time and the mean packet inter-arrival time at a streaming node. However, these mechanisms have the drawback that the streaming information should be known directly to streaming nodes, and the base station needs all information for resources of streaming nodes on the wireless link.

Lee et al. [13] proposed a transmission rate monitoring (TRM)-based multimedia streaming optimization method to improve the streaming quality of service (QoS) by considering minimum bandwidth, maximum bandwidth, and transmission rate in multimedia application domains. However, this mechanism has the drawback that the streaming node should be known directly the status of resources.

Yan et al. [20] proposed a media-friendly service mechanism to improve the streaming quality of service (QoS) by using utility-based model. This mechanism used two time slots: the one for video quality and the other for transmission control protocol (TCP)-friendliness. All of these mechanisms, however, suffer packet loss in case of congestion and suffer degradation of the overall system performance in wireless channel.

Thus, in the point of streaming media services, we find that the existing mechanisms are not well appropriated for supporting the user-centric streaming media service. Table 1 shows the comparison of the existing mechanisms.

Table 1. The comparison of existing mechanisms

Approach used	Advantages	Disadvantages
A selective caching mechanism [16]	Assuring the playback quality.	Does not cache service frames directly.
A hierarchical caching mechanism [17]	Reducing the service load.	The problem of high cost due to latency.
ORG (Object Relation Graph) [18]	Assuring the streaming service for clients.	The latency due to different service environments.
Priority-based Congestion Control Protocol [19]	Reduction of the startup delay and service traffic due to congestion control.	Excessive packet loss.
Transmission Rate Monitoring [13]	Assuring the quality of streaming service.	Should be known the status of resources directly.
TCP-friendliness [20]	Assuring transmission friendliness.	Packet loss due to congestion.

3. Grouping Mechanism.

3.1. Grouping by μ-cut. In the process of acquiring conceptual objects, if there is a similarity relation satisfying the properties of grouping, the conceptual objects can be grouped. Otherwise, the conceptual objects cannot be grouped.

Generally, the similarity relation is determined in the process of acquiring conceptual objects, and it is important to find the Most General conceptual Object (MGO) among conceptual objects. The Most General conceptual Object (MGO) determines which conceptual object is grouped, and is operated in connection with other conceptual objects.

The parameters which determine the similarity relation using Most General conceptual Object (MGO) are shown in Table 2.

Table 2. Parameters which determine similarity relation

Parameters	Meaning
C(S)	Object set which has properties of conceptual objects
MGO	Conceptual object which is most generalized in C(S)
MC(S)	Conceptual object which satisfies the properties of MGO among C(S)
MGC(S)	Conceptual object which satisfies μ-cut with MGO among MC(S)
CPM(S)	Conceptual object for carrying out fuzzy filtering in a group
CPM(N)	Conceptual object which does not satisfy fuzzy filtering in a group

A set of the matched conceptual objects is represented as a MC(S) = {CPM(S) − CPM(N)}. A Most General conceptual Object (MGO) is a conceptual object that is most generalized in C(S) and carries out μ-cut to determine the similarity relation.

Fuzzy filtering is proposed based on μ-cut [21] to determine the similarity relation of conceptual objects, and the fuzzy filtering is defined as follows.

Definition 3.1. *fuzzy filtering* $= \{c|MC(S) \geq \mu\}$

Here, MC(S) $\geq \mu$ is a set which satisfies conceptual objects.
MC(S) $\geq \mu$ must satisfy the following conditions:
Condition 1. Reflexive relation: $\mu(O_i, O_j) = 1$
Condition 2. Symmetric relation: $\mu \approx (O_i, O_j) = (O_j, O_i)$
Condition 3. Transitive relation: $\mu(O_i, O_k) \geq \min\{\mu\text{-cut} \approx (O_i, O_k),\ \mu \approx (O_j, O_k)\}$

A transitive relation determines similarity by μ-cut, and μ is a membership function with a fuzzy value between 0 and 1. Here, μ is an important parameter which determines the relationship of MC(S).

Fuzzy similarity represents the relation of objects and μ-cut is defined as the following.

Definition 3.2. $(\mu - cut) = \{O\,|MC(S) \geq \mu\}$

Figure 1 presents a hierarchical structure obtained by μ-cut.

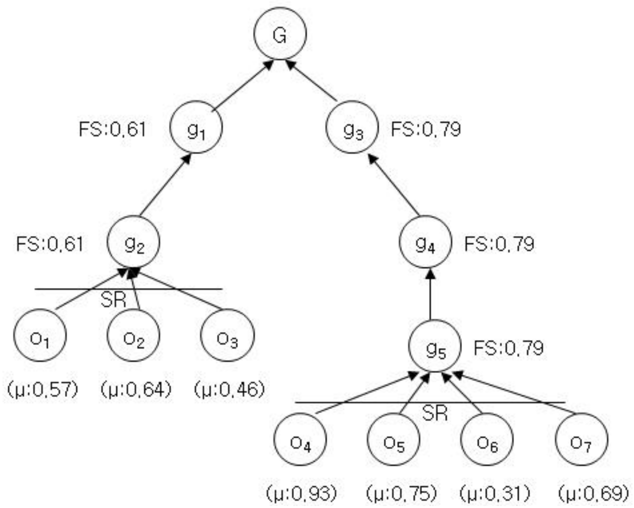

FIGURE 1. Hierarchical structure by μ-cut

Here, o_1, o_2, o_4, o_5, and o_7 are nodes that have a similarity relation, but o_3 and o_6 are opposite nodes. As shown in Figure 1, if g_2 is $\{o_1, o_2, o_3\}$ and g_5 is $\{o_4, o_5, o_6, o_7\}$, then CPM(N) will be $\{o_3, o_6\}$ and MC(S) will be $\{o_1, o_2, o_4, o_5, o_7\}$. If o_1 and o_7 are most general conceptual object, these will be carried μ.

As shown in Figure 1, since the o_3 and o_6 nodes do not satisfy the similarity relation, these are filtered, and the grouping happens toward g_2, g_1, g_5, g_4, g_3 and G.

3.2. **Grouping by FS.** We now discuss the process where we determine the similarity relation by fuzzy similarity (FS) when a new conceptual object is inputted. The grouping process must immediately determine the similarity relation, while acquiring the conceptual objects, and if the fuzzy similarity (FS) meets conceptual objects which do not satisfy the similarity relation, the object will be filtered. In specifying fuzzy similarity (FS), we define the following.

Definition 3.3. $FS = \left\{\frac{O|MC(S) \geq \mu}{Size(N)}\right\}$

Here, Size(N) is the number of conceptual objects which satisfy MC(S) $\geq \mu$.
Based on Definition 3.3, FS is achieved as follows:

Step 1. Fuzzy similarity processing about conceptual objects

```
procedure fuzzy_value relation()
{
  procedure fuzzy_relation(o_i, o_j)
  // Fuzzy filtering process about conceptual objects.
  procedure extend_search(o_k)
  // extend searching for fuzzy filtering.
    for(i = 0; i++)
      fuzzy filtering(o_i, o_{i+1})
      extract MC(S) ≥ μ
}
```

Step 2. Grouping creation

```
procedure extend_search()
{
  create fuzzy similarity about a new conceptual objects
  for(i = 0; i++){
    if (μ-cut) = {O |MC(S) ≥ μ}
    create Group(o_i)
    // create object groups about a new conceptual object.
  Else
    Step 1
}
```

Table 3 shows the parameters for grouping by Step 1 and Step 2.

Table 3. Parameters for grouping

NEW(C)	Conceptual objects for FS
FS(C)	Conceptual objects for MC(S) $\geq \mu$ in NEW(C)

If FS meets a new conceptual object for deciding the similarity relation, MC(S) processes CPM{FS(C)∪{C_i} − CPM(N)}. If FS encounters new conceptual objects which do not establish a similarity relation, MC(S) processes {(NEW(C) − CPM(N∪(O_i)))}. In determining FS, the similarity relation is determined by the disjunction of MGO and MC(S) $\geq \mu$ among MC(S).

As shown in Figure 1, if the current most general conceptual object is o_7, and a new object node of NEW(C) is MC(S) ≥ 0.69, CPM{MC(S) ∪ NEW(C)} is {o_4, o_5, o_7} and CPM(N) is {o_6}.

As an example, let us assume the following object domain on OD_1, OD_2, and OD_3: properties of conceptual objects on OD_1 is (o_{11}, 0.75), (o_{12}, 0.72), (o_{13}, 0.77), properties of conceptual objects on OD_2 is (o_{21}, 0.83), (o_{22}, 0.85), (o_{23}, 0.52), and properties of conceptual objects on OD_3 is (o_{31}, 0.65), (o_{32}, 0.68), (o_{33}, 0.23). If μ-cut is $\{O\,|\text{MC(S)} \geq 0.75\}$, then grouping on OD_1, OD_2, and OD_3 will be created {(o_{11}, 0.75), (o_{13}, 0.77), (o_{21}, 0.83), (o_{22}, 0.85)}.

Generally, the similarity is affected by the size of the media. Therefore, if we apply MC(S) $\geq \mu$ on a media object of the object domain, streaming media services are increased effectively.

3.3. **Grouping by DSR.** In this section, we suggest a grouping method that correlates conceptual objects by direct similarity relation (DSR). This method involves automatic insertion into an existing group when a new conceptual object is applied. If all conceptual objects of group G_2 in Figure 2 satisfy the properties of group G_1, then group G_1 subsumes group G_2, or $G_2 \subset G_1$.

Direct similarity relation (DSR) is determined by a fuzzy value that describes the properties of conceptual objects, and is defined as follows.

Definition 3.4. *If all super groups of G_i subsume subgroup G_j and the property restriction of G_i subsumes the property restriction of G_j, then G_i subsumes G_j. Then, if group G_i subsumes group G_j, similarity relation is $(G_i \subseteq G_j) = \{T, F\}$. In this relation, T means that the similarity relation is established, and F means that it is not.*

Definition 3.5. *If Definition 3.4 is established and there is a similarity relation where one element of subgroup G_j refers to super group G_i directly which satisfies MC(S) $\geq$ MGO in MC(S), then:*

$$DSR\{(o_i, \mu),\ G_i \geq MGO\} = \{o_i \in G_i \,|G_i \text{ subsumes } o_i\}$$

is $DSR\{(o_i, \mu), G\} = \{(o_i, \mu) \subseteq G\}$.

Here, o_i is a conceptual object of group G_i, G_i is a group that satisfies MC(S) $\geq$ MGO in MC(S).

Now, to process a new conceptual object, if necessary, an existing group must be defined and a group for streaming media services must be expanded and reconstructed incrementally. To process streaming media services, it is necessary to discriminate the existing group that satisfies definitions.

For example, if we suppose that there is a group "dog" and conceptual objects of poodle and jindo-dog satisfy all the restrictions of "dog", similarity{(a poodle, a jindo-dog), a dog} = {T}.

As shown here, if there exists a semantic similarity between conceptual objects, the grouping can be created. In other words, SR{(a poodle, a jindo-dog), a dog} is made of identical properties among the members of a group that (a poodle, a jindo-dog) have. This is the principle that the group "dog" is generated by the semantic similarity between "poodle" and "jindo-dog".

Figure 2 is an example of establishing grouping by DSR.

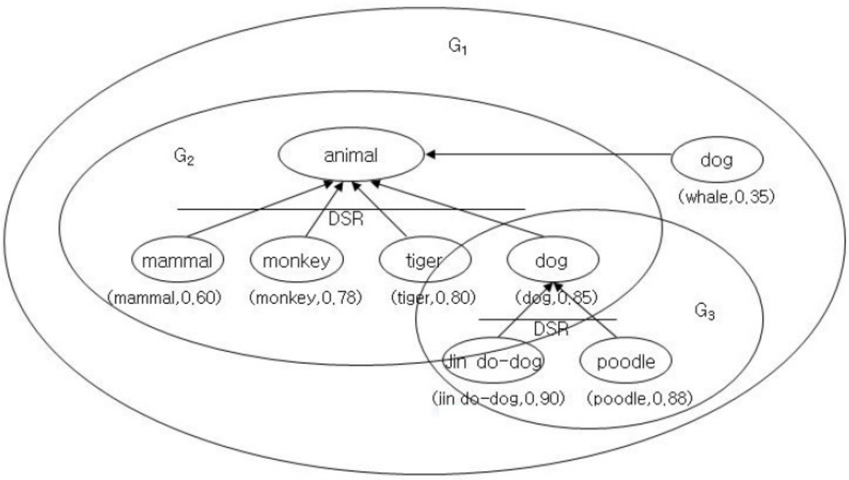

FIGURE 2. Conceptual object grouping by DSR

DSR about G_2 with Definition 3.4 and Definition 3.5.
① DSR{(mammal, 0.6), animal} = {(mammal, 0.6) ⊆ animal}
② DSR{(monkey, 0.78), animal} = {(monkey, 0.78) ⊆ animal}
③ DSR{(tiger, 0.80), animal} = {(tiger, 0.80) ⊆ animal}
④ DSR{(dog, 0.85), animal} = {(dog, 0.85) ⊆ animal} and DSR about G_1
⑤ DSR{(jindo-dog, 0.90), dog} = {(jindo-dog, 0.90) ⊆ dog}
⑥ DSR{(poodle, 0.88) dog} = {(poodle, 0.88) ⊆ dog}
If G_1 and G_2 can establish relation of DSR about G_3,
⑦ $\mathrm{DSR}\{\{G_1, G_2\}, G_3\} = \{\{G_1, G_2\} \subseteq G_3\}$
If constraint = "zoo" is given, the group "dog" is subsumed by the group "animal" but it is not subsumed by the group that is related to the zoo. Consequently, as this has the effect of increasing the throughput of streaming, the service efficiency can be improved.

4. **Simulation Results.** We have simulated the efficiency of the grouping method using 5,000 conceptual objects of news videos. For the evaluation of the suggested method, we utilized SQL server 7.0, Microsoft Visual C++6.0, and MFC of Windows 2003. We limited the depth of the group path to between 3 to 6. If the depth of group paths is too small, too many related conceptual objects are streamed. If the depth of a group path is too large, there are too few corresponding conceptual objects. The stream time and the streaming efficiency are evaluation criteria related directly to the client's request. The stream time means the period between starting queries and obtaining the results of streaming.

In this paper, we measured the total average streaming time about each conceptual object that composes a group. We assume that all the conceptual objects which belong to the same group belong to the same file. To inspect the streaming efficiency of the suggested method, we use:

$$CO_{search\ time} = CO_T\left(1 + \frac{1}{N}\right) + \left\{\left(\frac{CO_T}{group\ G_i}\right)\right\} \times O_{random}$$

Table 4 shows the parameters for streaming efficiency.

TABLE 4. Operators for streaming efficiency

Parameters	Meaning
CO_N	The number of conceptual objects
CO_{time}	The time spent in streaming corresponding conceptual objects which satisfying MC(S) $\geq \mu$ in group G_i
GCO_{time}	The time spent in streaming conceptual objects which satisfying FS
$DIST_{time}$	The time spent in moving group to group
μ	Fuzzy value for FS
S_{cache}	Cache capacity for streaming the conceptual object
T_{cache}	Total cache capacity for streaming conceptual objects of group G_i

Consequently, when we suppose there are N groups for a streaming service, the time spent on streaming corresponding conceptual objects is $\mathrm{CO}_{time} = GCO_{time} + DIST_{time} \times CO_N$, and the time spent on searching conceptual objects which satisfy FS in group G_i is $GCO_{time} = x(CO_i) + y(CO_j)$.

Here, $x(CO_i)$ means the total average time to stream conceptual objects which satisfy MC(S) $\geq \mu$ in group G_i, and $y(CO_j)$ means the total average time to access the related conceptual objects which satisfy fuzzy similarity in group G_i.

For the wireless mobile network set-up, we enable RTS/CTS and implement the distributed coordination function (DCF). We choose the wireless channel bit error rate (BER) to be $1.5 * 10^{-5}$. The link layer transmission delay is 0.1 μs, and the maximum number of link layer retransmissions is 3. The data rate of the wireless channel is 512 Kbps, and only up to 1 Kbps out 512 Kbps will be used for streaming service. For each mobile client, the maximum allocated bandwidth for streaming service will be 1 Mbps for the proxy-to-client connection and 256 Kbps for all client-to-proxy connections. Each group is simulated five times to obtain the streaming throughput, the average service response rate, and the average cache hit rate. The average service response rate is the average rate of the service requests without a timely response.

The latency time rate is the delay time from the average service response time. The average cache hit rate is the average number of appropriate data to that of total data transferred to clients in the proxy caching server.

To inspect the performance of the suggested efficiency, with 5,000 news videos as conceptual objects, 5 simulations were done for each conceptual object satisfying MC(S) $\geq$ 0.6-cut in group G_i, and the averages were calculated. Also, we limited the maximum group degree to 5. Figure 3 shows the streaming throughput with MC(S) $\geq$ 0.5-cut and MC(S) $\geq$ 0.8-cut.

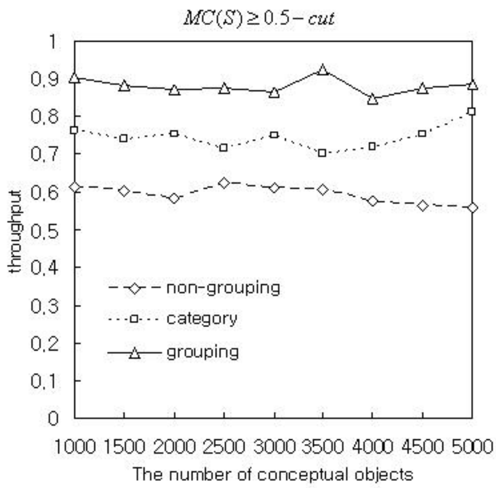

FIGURE 3. Streaming throughput with MC(S) $\geq$ 0.5-cut

Figure 4 shows the average streaming throughput of 10 simulations when CO_N is 5,000. In the simulation result satisfying MC(S) $\geq$ 0.5-cut and MC(S) $\geq$ 0.8-cut, we can judge whether the grouping method is superior to the non-grouping method and category-based method. With regard to the streaming efficiency, the proposed method improved the streaming throughput compared with the non-grouping method and the category-based method. So, we can see that the proposed method is superior to the other methods.

Figure 5 shows the average service response rate with $CO_N = 5,000$ and MC(S) $\geq$ 0.1-cut.

As shown in the figure, non-grouping schemes have the lowest average service response rate due to the mixed streaming of small burst media objects and large burst media objects. Large burst media objects aggravate congestion, jitter delay, and re-transmission. The proposed method, however, does not show aggravation in the average service response rate with the increase of conceptual objects. The reason for this is the reduction of congestion and re-transmission owing to the decrease in startup latency and jitter delay

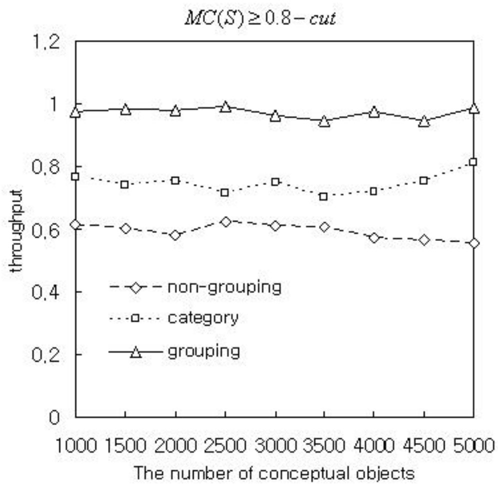

FIGURE 4. Average streaming throughput

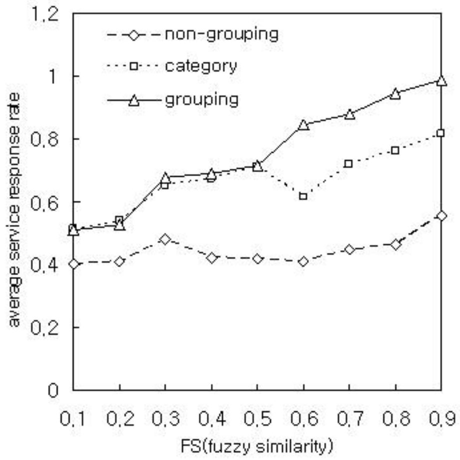

FIGURE 5. Average service response rate with $CO_N = 5,000$ and MC(S) $\geq$ 0.1-cut

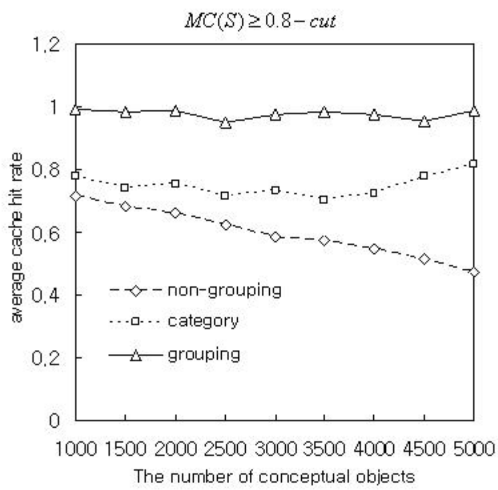

FIGURE 6. Average cache hit rate with $CO_N = 5,000$ and MC(S) $\geq$ 0.8-cut

due to the grouping of more relevant conceptual objects. Thus, more popular conceptual objects in the same group enable improved user-centric streaming services.

Figure 6 shows the average cache hit rate with $\mathrm{CO}_N = 5,000$ and $\mathrm{MC(S)} \geq 0.8$-cut. As shown in the figure, the non-grouping method showed the lowest performance since conceptual objects are not grouped, whereas the category-based method had relatively improved performance. The performance of the category-based method is not as high as that of the proposed method, since the category-based method is not adaptive for the encoding rate and bandwidth since it does not apply fuzzy similarity.

According to the simulation result, the performance depends on the value of fuzzy similarity, and is relatively high for μ-cut with $\mathrm{MC(S)} \geq 0.8$-cut. The use of the simulation result improved the average service response rate by 50% and the average cache hit rate by 15% when the total cache size was less than 80%.

Thus, the proposed method has improved performance in the average service response rate and average cache hit rate owing to the use of fuzzy filtering determined by fuzzy similarity. The proposed method enables user-centric streaming media services with improved QoS by the control of jitter delay, congestion, and re-transmission using grouping.

5. **Conclusions.** A new conceptual object grouping method has been proposed for user-centric multimedia services with μ-cut, fuzzy similarity, and direct similarity relation (DSR) structure, so that streaming media services can be served with automatic fuzzy-filtering as the size of the conceptual objects becomes larger.

The proposed method keeps streaming information in groups and caches it systematically, enabling users to serve the streaming information of objects effectively. To date, segment-based proxy caching method has been proposed as the service of media objects.

The proposed grouping method has the advantages that provides formal information as well as informal media information to mobile clients. The similarity relation between the conceptual objects applied μ-cut, fuzzy similarity, and direct similarity relation (DSR), and the simulation results showed that the proposed method provides better performance than the non-grouping method and category-based method.

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