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# A Peer Collaboration Scheduling for Mobile P2P Streaming Services

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***Abstract***

*In the IoT environment in which not only in smart services such as augmented reality, virtual reality but also consumers, manufacturers, utility companies take part, it is necessary to accommodate diverse smart grid infrastructure as well as Internet. And for these services, the methods utilizing the P2P protocol have been proposed. This paper proposes a way to effectively utilize the resources of the network and the mobile node when there is a need for service to synchronize various types of media streams on the client side in the P2P mobile environment, which has a high adaptability to a heterogeneous network. in order to analyze the proposed method, it compared them to the normal P2P protocol having a conventional mesh structure, which they showed a better result by more than 25% in the nodes available to service and service request rejection rate. Furthermore, it also proposed a real time synchronization for multimedia, including a short time interval first (SIF), a long time interval first (LIF), and central stream block first (MSF). Therefore, it showed that the central stream block first scheme (MSF) has advantages in case of synchronizing various stream blocks for service.*

***Keywords****: Node, Collaboration, P2P, Component Structure, Composite Media*

## 1. Introduction

Having developed with the beginning with Napster, P2P (Peer-to-Peer) is a technique that breaks away from a centralized resource distribution service and enables decentralized resource sharing and distribution. Since PC-to-PC connection, the basic concept of P2P, eventually means a user-centered, direct connection between the users, it has been a proper way applicable to various businesses in social organizations at different levels. Moreover, as numerous objects come to participate in cyberspace, P2P has an important role in creating and spreading a new culture.

P2P networks, based on decentralized networks, can be classified into Structured ones and Unstructured ones [1]. The Unstructured P2P, with no specific server, maintains the network and provides service only with peers. Therefore, while it is flexible to the changes of network, the exploration phase can be extended, and the message delivery can result in excessive traffic.

On the other hand, Structured P2P is often applied to a method to create and manage Tree for providing P2P-based Multicast service using Distributed Hash Table (DHT). The best examples of DHT-typed P2P networks are Chord [2], CAN [3] and others. Recently, in the mobile smart service environment such as augmented reality, virtual reality, IoT, there occur the cases in which the stream blocks of different types need to be synchronized to match the user's service requirements. However, the existing P2P services may not satisfy diverse environments and requirements of the client node.

This paper proposes a way to receive service selectively according to the environment of the network and the client regarding the complete form of composite media and component media. This approach improves the duplicate storage of the relevant stream

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block within the mobile P2P network, enabling smoother cooperative distribution between the nodes. It also proposes a method for the synchronization arrangement to reduce the buffer usage of the mobile node. Chapter 2 will examine the P2P structure for media streaming services. Chapter 3 will discuss the extended media service plans suggested in this paper as well as the synchronization arrangement method. Chapter 4 will simulate the scheduling policies proposed in this paper and attempts a comparative analysis with the conventional method. Finally, Chapter 5 will briefly describe the future research directions with a conclusion.

## 2. P2P Structure for Media Stream Services

The structures for the media stream service in the P2P environment include a single tree structure, multiple-tree structure, the hierarchical cluster structure, a mesh structure, and others.

A single tree structure that allows a parent node and a child node is a simple structure in which a node only maintains control information of a parent, sibling, and child node. However, if a parent node has a defect, every child node cannot receive services, and many child nodes need to find a new parent node for contact. The typical methods will be P2VOD [4], P2Cast [5].

The multiple-tree structure proposed to address the problems caused by the disconnection with a parent node builds the nodes that are joined to the system in a multi-distribution tree. As the child nodes can receive a stream from parent nodes, it reduces the chance of losing the entire stream, which can be caused by parent nodes' leaving. However, as the server must have complete information of the distribution tree, it may experience overloading and Startup Delay for the control. Typical methods include CoopNet [6] and Gnutella [7].

ZIGZAG [8,9], as hierarchical cluster structure, serves to disperse the load of the server or distribution node by keeping the server cluster or distribution node cluster. However, the hierarchical cluster is not highly applicable to the Internet environment that utilizes flexible networks.

NARADA [10] has been proposed as Multiple Source Multicast Overlay Infrastructure, which consists mesh structure for the relationship between each node and builds a tree for the data transmission. Since the mesh structure is highly adaptable to a heterogeneous network in particular, it can be described as having advantages in the current mobile environment.

In the IoT environment in which not only in smart services such as augmented reality, virtual reality but also consumers, manufacturers, utility companies take part, it is necessary to accommodate diverse smart grid infrastructure as well as Internet. And for these services, the methods utilizing the P2P protocol have been proposed [11, 12, 13, 14, 15]. VON [11] divided the entire game areas into multiple virtual areas in Multiple Access P2P virtual environment game and made it possible that when the messages were sent and received between participants in the game (nodes) in the field of interest, only the message within the virtual area would be sent. Thus, it proposed an effective way to deliver messages. That is, it used Voronoi-based Overlay Network in order to maintain the connection between the nodes based on the current position in the game area and formed the P2P structure using Voronoi Diagram.

This paper proposes a way to effectively utilize the resources of the network and the mobile node when there is a need for service to synchronize various types of media streams on the client side in the P2P mobile environment, which has a high adaptability to a heterogeneous network.

## 3. A Peer Collaboration Scheduling for Mobile Streaming Service

In general, P2P network brings the whole list of the nodes holding the relevant streams from the super peer when one node is to download a specific stream, and in this case, the relevant peer makes a list of candidate peers using this list. From the position of the client node, on the other hand, in the case in which the play is carried out after the complete download of the media, the storage of the total length of the stream must be secured in the client node, and thus it is unable to efficiently use the resources of the node. Meanwhile, even though the mobile device has the advantage of freely access to the network, it has limits in its own resource utilization for bandwidth or mobile devices. Therefore, the failure or replacement often occurs for nodes. For the way that carries out the download and streaming at the same time, only the part to be played can be restored, which can reduce storage area. However, for a smooth streaming, it should be able to effectively use the bandwidth of a network. This problem is related to the problem of increasing the number of nodes in the P2P network that can provide service (type of media).

In this paper, we propose the following measures to overcome these problems. (1) Expand the media utilization to increase the number of nodes that can participate in services (2) Effectively utilize the buffer or storage capacity of the mobile device by synchronizing only the required media (3) Shorten the initial waiting time at the time of synchronization of component stream block.

### 3-1. Peer Collaboration Scheme

Let us define synchronization-complete multimedia sources as $V$. In media $V$ , there exists related component media such as { $V_1, V_2, V_3, V_4, \cdots\cdots V_n$ }. For example, in $V$, all or part of the video sources, subtitles, and sound, the media information, images, smart information can be synchronized. Figure 1 shows A Peer Collaboration Scheme for extended component service.

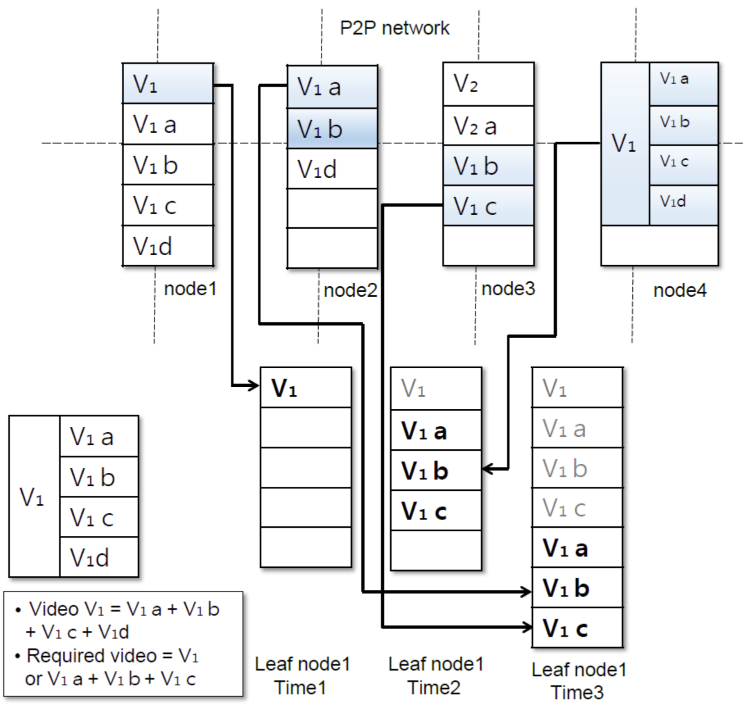



**Figure 1. Peer Collaboration Scheme for Extended Component Service**

Required $V_1$ is composite multi-media composed of media $V_{1a}, V_{1b}, V_{1c}, V_{1d}$. In some of the nodes in P2P network, there exists not only synchronized media $V_1$ but also $V_{1a}, V_{1b}, V_{1c}, V_{1d}$, not synchronized but managed as a single file. In another node, $V_{1a}, V_{1b}, V_{1c}, V_{1d}$, a component of $V_1$ is stored in an independent form. Initially, it has a composite multimedia source $V_1$ among P2P nodes and searches for a node possible to provide stream service at the current time ($time_1$). If a possible node ($node_1$) exists, it will execute service of source $V_1$ from the corresponding node. If, at one point ($time_2$), $node_1$ leaves from the network or the transmission speed is lower than the minimum guarantee speed ($Trs_{\min}$), the next step will be followed. That is, the nodes that include $V_{1a}, V_{1b}, V_{1c}, V_{1d}$, which is not synchronized but packaged in one file, will be searched.

If the corresponding node ($node_4$) exists, stream service will be executed in $time_2$. If network errors occur again in $time_3$ the same as in $time_2$, the node, in which media $V_{1a}, V_{1b}, V_{1c}, V_{1d}$, the component of $V_1$, exist in an independent form, will be searched and service will be run. That is, the extended stream service method proposed in this paper can expand service opportunities by dealing not only with synchronized composite media with a single stream but also with component media streams before synchronization. In addition, it can be synchronized by selecting only the necessary media depending the country or environment among multiple sound channels and multiple languages, multiple subtitles, and therefore, it can save network traffic or the buffer of a mobile node.

In order to provide services for the extended media stream, you should be able to effectively refer to the source node ID that stores Type-specific component block. Figure 2 shows the Component Reference Bucket List. The List is composed of Multimedia Component Structure and Source Bucket List.

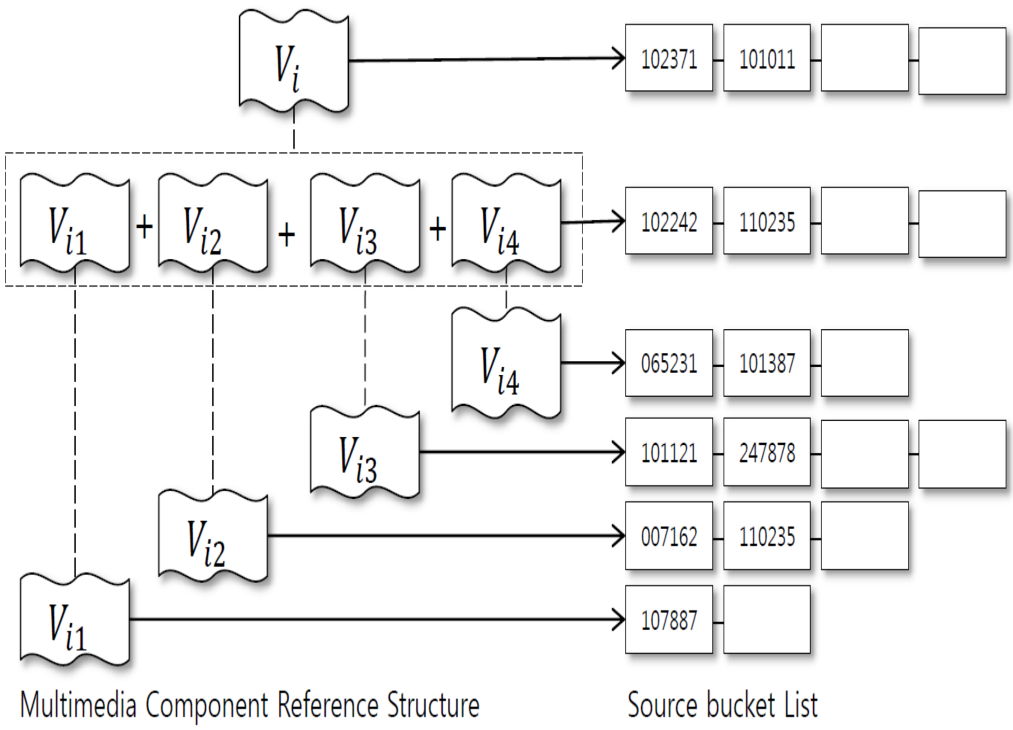



**Figure 2. Component Structure and Bucket List**

Multimedia Component Structure indicates the type of source media available to stream services hierarchically and, Source Bucket List is the ID of the source nodes in the P2P network that can be referred to in relation to the Multimedia Component Structure.

In the extended component service, it is composed of six Bucket List and three kinds of streams to provide services to multimedia block $V_i$. Therefore, it is possible to increase the redundancy of the service stream in the P2P network, giving the client node an increased opportunity to receive a media stream service.

### 3-2. Real-time Synchronization

In order to extend the service components in the P2P network, it is necessary to synchronize them in real time in the receiving node.

The effective Inter-Media Synchronization of the dispersion media after receiving it from the receiving node is already well-known.

This paper proposes an efficient way to utilize resources in the case of a node when running download and streaming at the same time from a mobile node in the P2P network. In general, when you download and stream at the same time, you can only save the part to be replayed in the next hour and thus the storage time can be reduced.

While the component media is transferred from the cooperation nodes having different bandwidth services and therefore it is necessary to establish a policy for the effective real-time synchronization of these media.

For example, for the Inter-Media Synchronization of the four component media blocks, it is necessary to list stream blocks according to Synchronization-Interval, and the four buffers is required, as shown in Figure 3. However, the more severe fragmentation in the buffer and the greater the time interval need for synchronization, the more intensifying is the fragmentation.

If we define media stream sent from cooperation node as { $V_1, V_2, V_3 \cdots V_n$ } and bandwidth as { $Vs_1, Vs_2, Vs_3 \cdots Vs_n$ } respectively, the minimum buffer size required for synchronization may be referred to $B_{\min} = LCM(Vs_1, Vs_2, Vs_3 \cdots Vs_n)$ using LCM (Least Common Multiple).

Speaking of the media stream sent from each node selected collaboration {} {referred to as, and bandwidth, respectively}, the minimum buffer size required for synchronization may be referred to by using the LCM (Least Common Multiple).

If we define a synchronization time interval in the media block as $V_bT_i$ , $\frac{1}{Vs_i} \approx Vs_i$ can be established. The necessary and sufficient condition for stream block { $Vb_1, Vb_2, Vb_3 \cdots Vb_n$ } to be synchronized within the minimum buffer $B_{\min}$ will be $\sum_{i=1}^{n} \frac{1}{VbT_i} \leq 1$. In this case, if $k$ is a synchronization factor, synchronization status in $k = \sum_{i=1}^{n} \frac{1}{VbT_i}$ will be shown in Table 1.

Figure 3 indicates stream block $Vb_1, Vb_2, Vb_3 \cdots Vb_n$ of media $V_1, V_2, V_3 \cdots V_n$, of which Synchronization-Interval is 3, 4, 4, 6 respectively, in Time-Line. In case of $V_4$, the greater the fragmentation, the more intensifying is synchronization time interval, and therefore,

it is necessary to merge four streams into one block. From $B_{\min} = LCM(3, 4, 4, 6)$, $B_{\min} = 12$ is followed, and the condition for these stream blocks to be scheduled to in one buffer satisfies $k = 1 = \frac{1}{3} + \frac{1}{4} + \frac{1}{4} + \frac{1}{6}$.

**Table 1. Synchronization factor**

| Equation | Meaning | Description |
|---|---|---|
| $k< 1$ | Buffer Starvation | Additional media blocks can be synchronized and added to a buffer. |
| $k= 1$ | Buffer Hit | Completely can be synchronized in a buffer with no space. |
| $k> 1$ | Buffer Overflow | New buffers need to be added. |

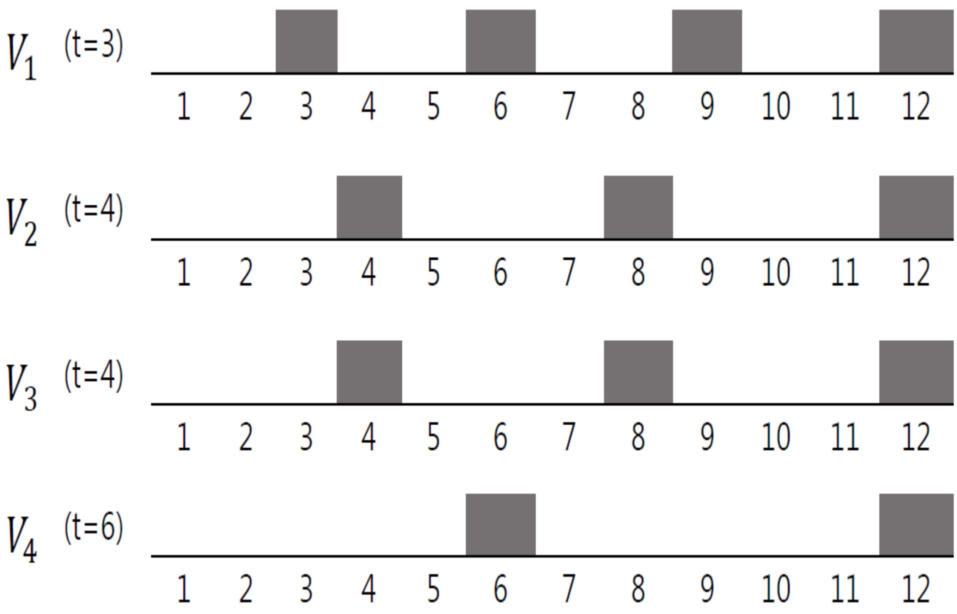



**Figure 3. Media Stream Listed in Synchronization Intervals**

### 3-3. Stream Blocks Placement

There can be a difference in the share of buffer and the initial service start time because even if multiple streams were merged into LCM-sized buffer, the time to complete initial synchronization is different depending on the stream arrangement. Figure 4 shows the effect of merging the streams blocks $Vb_1, Vb_2, Vb_3 \cdots Vb_n$ in Figure 3. Case1, Case2, Case3 are each a short time interval first (SIF), a long time interval first (LIF), central stream block first (MSF) method.

| Case 1 | $V_1$ | $V_1$ | $V_1$ | $V_1$ | $V_2$ | $V_2$ | $V_2$ | $V_3$ | $V_3$ | $V_3$ | $V_4$ | $V_4$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |

| Case 2 | $V_4$ | $V_4$ | $V_3$ | $V_3$ | $V_3$ | $V_2$ | $V_2$ | $V_2$ | $V_1$ | $V_1$ | $V_1$ | $V_1$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |

| Case 3 | $V_1$ | $V_2$ | $V_3$ | $V_1$ | $V_4$ | $V_2$ | $V_1$ | $V_3$ | $V_4$ | $V_1$ | $V_2$ | $V_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |

**Figure 4. Synchronization Completion Time Depending on Buffer Merger Method**

SIF method, among stream blocks, places them in LCM buffer with the shortest Synchronization-Interval of stream block first, and initial synchronization is completed in the 11th.

LIF method is a method of arranging the LCM buffer to the stream, with the longest sequence of blocks first and the initial synchronization is completed in the 9th Time-Interval.

Meanwhile, MSF method is to place the stream blocks with the shortest time-interval and central to synchronization (videos, for example) first and then place the stream blocks with longer time-interval.

If you use this method, the initial synchronization is completed at Time-Interval 5-th, and thus you can reduce the service start time and buffer share.

## 4. Performance Evaluation of the Proposed Model

### 4.1 Experimental Environment

The main interest of the extended P2P policies proposed in this paper is to have an effective way for the service and the resource utilization for the mobile device when the media stream needs to be treated on different types of wireless P2P network.

Therefore, we proposed expanding the types of media streams and a real-time synchronization mechanism, considering the service start time. In order to evaluate the performance of this paper, we use the simulation technique based on the following standards.

(1) to analyze nodes available to service (2) to measure the initial delay time (3) the average buffer usage of the mobile node (4) service rejection rate due to defects in the node or lack of contents.

**Table 2. Parameter Table**

| Variable | Value | Variable | Value |
|---|---|---|---|
| Number of Nodes | 600 | Number of Stream Blocks | 600/stream |
| Network Bandwidth | 10.0Mbps (node) /100.0Mbps (router) | Size of Stream Block | 512 Byte |
| *Playback Bandwidth* | 4.0/3.0/3.0/2.0 Mbps | Synchronization Interval | 3.0/4.0/4.0/6.0 msec |
| *Service Arrival Rate (According to λ)* | 1/sec | Node Failure Interval | 60sec |

For the entire network, up to 528 nodes can take part, and it consists of a total of 24 Stub Domain. One domain consists of 22 nodes and three routers. Composite media for a service is the stream $V$ of 60 minutes' length. Other than expanded P2P scheme, it is assumed that there are { $V_1, V_2, V_3, V_4$ } in package form and $V_1, V_2, V_3, V_4$ in an independent form. Arrival rate of the common node follows Poisson distribution (Poisson distribution), and the newly arrived node will participate in a random position in the network. In addition, a node generates a Connection Failure per 1 minute. It is used to analyze the degree of disability caused by any defects in the service stream node. Other details are indicated in Table 2.

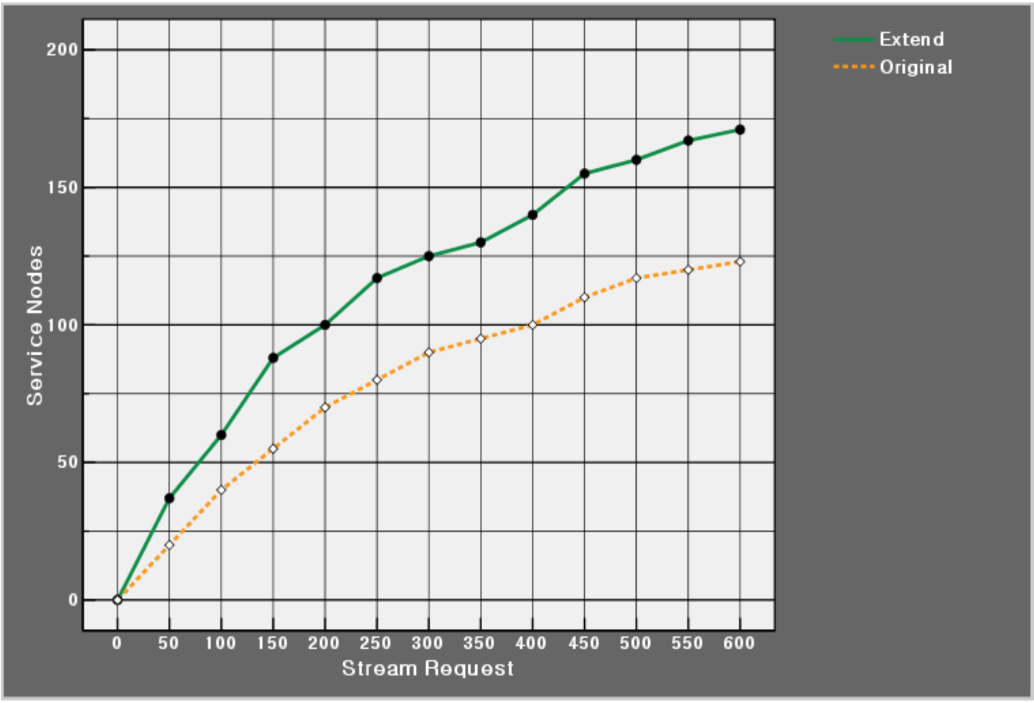
### 4.2 Analysis of Services Involvement Node

Figure 5 shows the number of nodes that store the relevant block if there is a service request for the stream block. Extend is a way to expand the media services proposed in this paper, and Original is a common method that applies common P2P protocol with a mesh structure. It shows that as the service requirements of the node increase may also have to be increased with increasing storage blocks for a particular stream, by the very nature of the P2P network. The average number of serviceable nodes are 111.54 for Extend and 78.46 for Original, and maximum number of nodes that can provide service is 1450 and 1020 respectively, which shows that the proposed method is more excellent by 25%. It can be analyzed that it is because Extend method that can handle the various component streams can improve stream redundancy within the network.

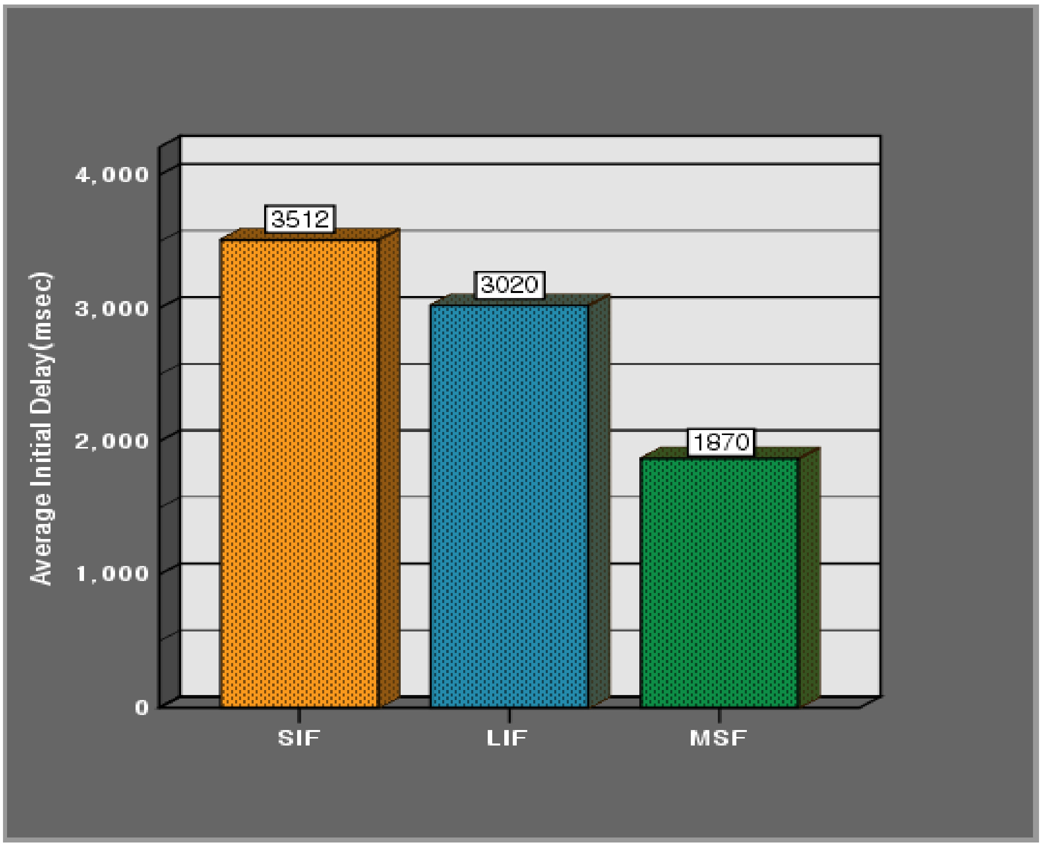
### 4-3 Analysis of Synchronization Method

Figure 6 and Figure 7 analyzes the characteristics of the three synchronization method using the proposed scheme. Average waiting time for Initial services for Short time interval first (SIF), a long time interval first (LIF), and the center stream block first (MSF) scheme is 3,512 (msec), 3,020 (msec), 1,970 (msec) respectively, which shows that MSF method, with instant synchronization, has shorter initial waiting time than the method of synchronization after storage by LCM unit. This is also related to buffer usage of the node.

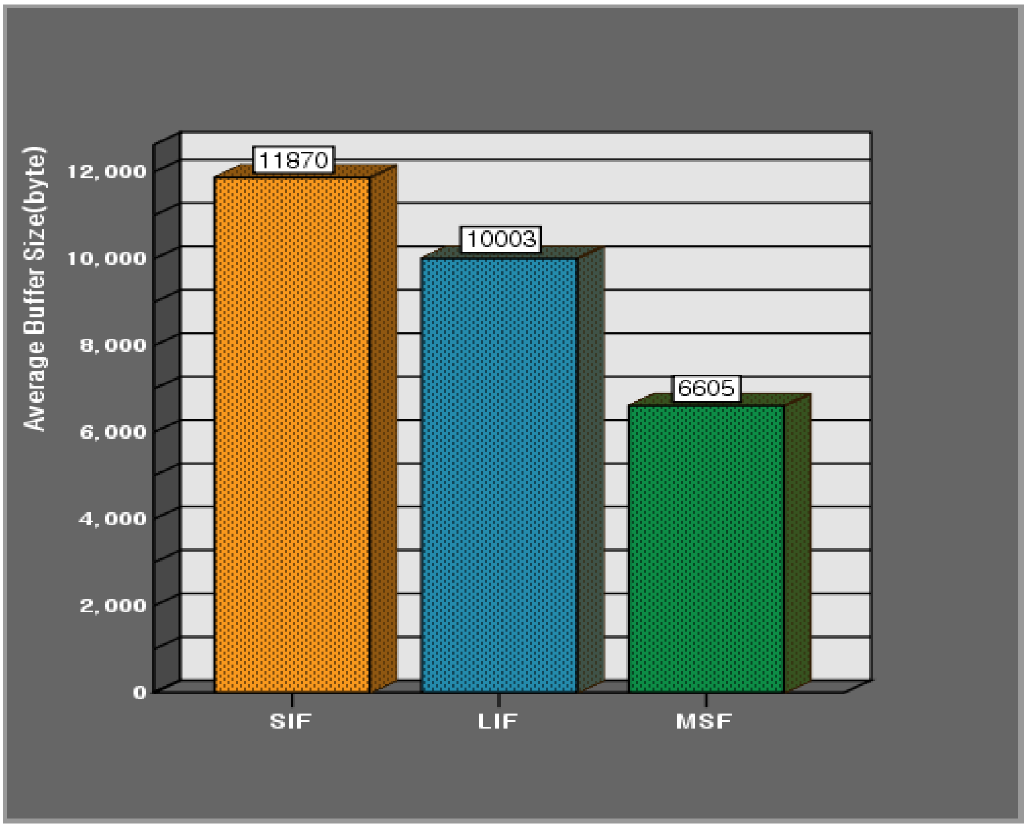



**Figures 5. Analysis of Participating Nodes**



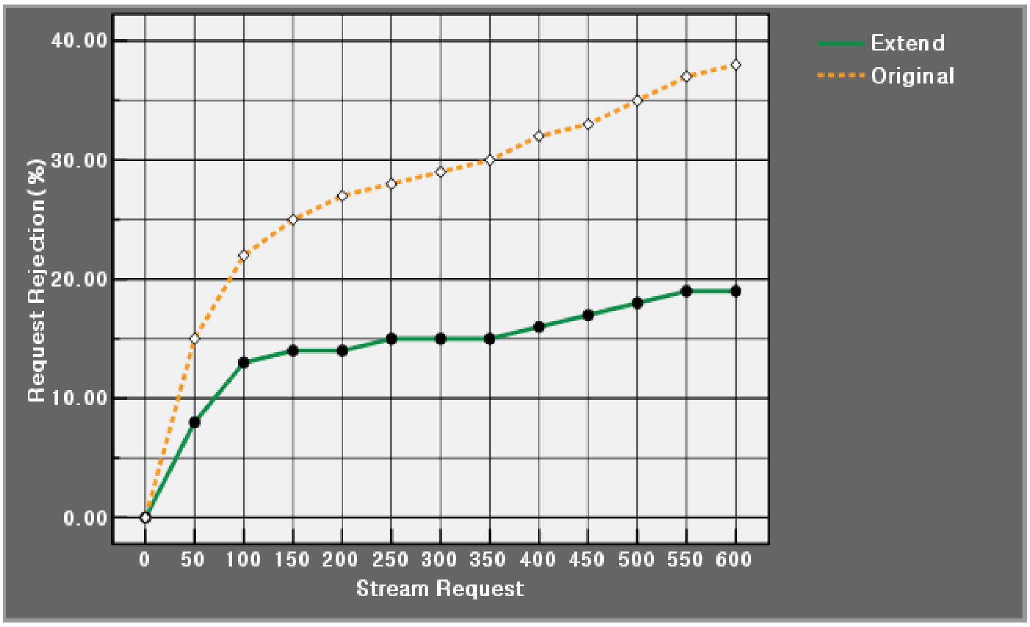

**Figures 6. Average Initial Delay According to Synchronization Techniques**




**Figures 7. Average Buffer Size According to Synchronization Techniques**

Next, MSF method shows a better result, with 11,870 (byte), 10,003 (byte), 6,605 (byte) respectively, also in average buffer usage.




**Figures 8. Service Request Rejection Rate**

**4-4 Service Request Rejection Rate**

When the network refuses to provide service at the request of a node for a particular stream block. That is because the relevant node storing the corresponding stream blocks is absent or bandwidth is lacking, or it can no longer provide services due to an error in the node. Figure 8 is a graph showing the service request rejection rate ( $1 - \frac{The\ Nmber\ of\ Acceptance}{The\ Nmber\ of\ Request}$ ) depending on the number of requests of clients asking for a service through the stream server. As for the average request rejection rate, Extend method shows 14%, Original scheme shows 27%, higher than the first. It can be analyzed that the reason why Extend has a lower service request rejection rate is the result of three-staged node search according to the component reference structure.

## 5. Conclusion

Existing P2P service, for the effective service for a single media, has sought cooperation between the nodes. Recently, however, not only smart services such as augmented reality, virtual reality but also IoT environment and diverse business services are required, and new technologies are being developed and expanded for this purpose.

Therefore, the P2P service in the future requires real-time synchronization of heterogeneous networks and various contents in accordance with individual needs as well as cooperation the nodes for the service. To solve this problem, this paper proposes a way to diversify the type of stream blocks for services and a real-time synchronization scheme of the composite stream blocks according to a user's needs. It also proposes a stream placement policy for storing them efficiently. In addition, in order to analyze the proposed method, it compared them to the normal P2P protocol having a conventional mesh structure, which they showed a better result by more than 25% in the nodes available to service and service request rejection rate.

Furthermore, it also proposed a real time synchronization for multimedia, including a short time interval first (SIF), a long time interval first (LIF), and central stream block first (MSF). Then it analyzed the average waiting time for the initial service, average buffer usage of the mobile node. Therefore, it showed that the central stream block first scheme (MSF) has advantages in case of synchronizing various stream blocks for service. Therefore, the proposed method can effectively utilize the buffer or storage capacity of the mobile device because it can increase the number of nodes that can participate in the service and selectively synchronize only the required media.

Currently, materializing this paper, studies are being conducted to realize a system, which can selectively synchronize various media types in the mobile node such as the augmented reality and virtual reality, and effectively provide services.

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