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# Extended Node Management Policy for Integrated P2P Network Services

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**Abstract**

Wireless network services for mobile terminals are actively underway. Therefore, the necessity to effectively provide the existing wired network-based P2P services in wired/wireless based integrated network environments is coming to the fore. However, since the mobile terminals that use wireless networks are characterized by the utilization of available resources, limited battery capacity, limitations of storage devices, and free mobility of terminals, their peer-to-peer connections are frequently disconnected and, consequently, their network configuration is drastically changed. Therefore, the wired network based peer scheduling policy is not suitable for wired/wireless integrated networks. To that end, in the present paper, an extended P2P peer management policy is proposed considering the characteristics of the terminals that receive P2P services on integrated networks. This policy is composed of a Degree Ordered Strategy and a Mobile P2P Service Strategy and shows the performance improved by ca. 25% or more as compared to the existing wired node-based TOT and BOT methods or the RJS method, which is specialized for mobile nodes in terms of the degree reconstruction for network recovery and service delay.

**Keywords**: P2P, mobile devices, VOD stream, Time-Ordered tree, Bandwidth-Ordered tree, wireless integrated network

## INTRODUCTION

Recently, mobile type terminals have been increasing in number on networks, and these terminals have been mixed with existing wired nodes in services. Therefore, to effectively process peers' services on P2P networks, all the characteristics of the access environments and multimedia contents of all peers existing on the network should be considered. Figure 1 shows the general overview of the wire/wireless P2P systems. The peers are divided into wired peers and mobile peers. Super peers for mobile nodes are selected from among those peers that have a high resource availability or a high loyalty to the network in the P2P network. The index server stores a list of nodes belonging to the wired/wireless P2P networks and the contents held by the temporary caching nodes. The link server plays the role of connection between wired/wireless networks.

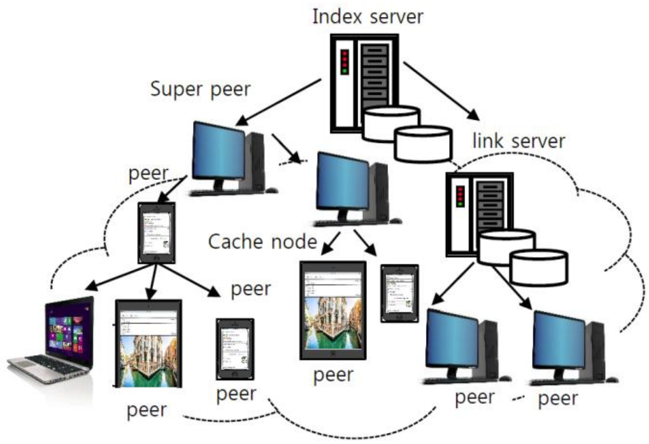


**Figure 1.** The general overview of the wire/wireless P2P systems

The cache node temporarily stores the blocks of frequently requested contents and directly provides the contents without going through the P2P service stage. Recently, MOVi (Mobile Opportunistic Video-on-Demand) has been proposed as a way to use a centralized scheduling server for mobile terminal devices that cannot but be lacking in resources due to the recent popularization of mobiles services [1, 2]. In addition, a study that extended e-DONKEY services, which can be said to be a precursor of P2P systems, into mobile P2P was also proposed [3]. Furthermore, a study of node join strategies for effective streaming services in mobile environments [4] and a study of effective peer allocation policies in mobile P2P networks [5] were also conducted. However, most of these studies are not suitable for network environments where wired/ wireless networks are mixed, because they are effective for certain networks. Therefore, for efficient P2P services in wired/wireless integrated environments, new strategies distinguished from conventional P2P stream services in content transmission and caching strategies according to node characteristics are necessary. In the present study, a node management policy considering the characteristics of peers in wired/ wireless P2P networks is proposed. In Chapter 2 of the present paper, studies related to network configuration policies in dynamic p2p environments are examined; furthermore, in Chapter 3, a node management policy efficient in wired / wireless integrated networks is proposed. In Chapter 4, the policy proposed in Chapter 3 is compared to the existing techniques and analyzed through experiments to evaluate the performance of the policy proposed in the present stud. Finally, Chapter 5, conclusions are presented.

## P2P NETWORK NODE MANAGEMENT POLICIES

### Dynamic P2P network node management policies

To efficiently provide media streaming services in P2P environments, a topology configuration stable against dynamic changes in the nodes participating in P2P services in the network [6] and node selection methods considering the reliability are necessary. Therefore, many algorithms have been proposed to construct trees stable in the dynamic environments of nodes [7, 8, and 9]. The depth optimizing algorithm and the time optimizing algorithm are representative ones [10]. The bandwidth-ordered algorithm, one of the depth-optimizing algorithms, allocates nodes with bandwidths first [11]. Since the bandwidth-ordered algorithm was configured according to the bandwidth, the depth of the trees is relatively small and less affected by the dynamic situations of the nodes. Meanwhile, the Time-Ordered algorithm is a method of arranging the nodes in order of the lengths of the time during which the nodes stayed in the system after being joined to the system. Since this method allocates the nodes considering the reliability of nodes first, the trees can be stably operated. Each tree constructed by the bandwidth-ordered algorithm or the time-ordered algorithm is called a Bandwidth-Ordered-Tree (BOT) or a Time-Ordered-Tree (TOT), respectively.

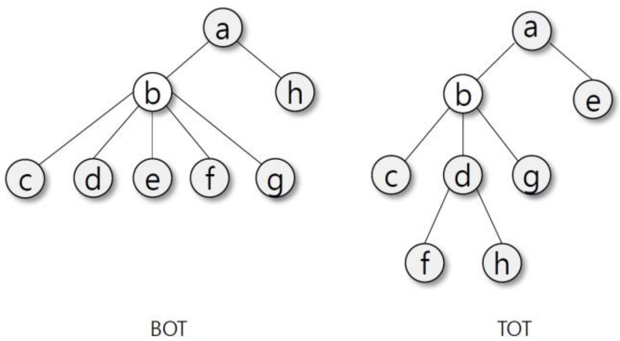


**Figure 2.** Tree Architecture in Dynamic Environment

Figure 2 shows the BOT and TOT methods for configuring the network trees. However, in the case of the BOT method, the generation of the tree may be distorted, because the parent nodes are searched in order of bandwidths and this may result in a bandwidth imbalance between the nodes. In addition, the larger the bandwidth is, the larger the number of child nodes may become. If this parent node goes out of the tree, the child nodes become missing in a moment and the recovery time for the tree will be long. In the case of TOT, since the order of nodes is determined based on how long the nodes stayed on the network, if the depth of the tree is too large, the dynamic situations of the nodes cannot be stably responded. Therefore, the overhead or delay may be lengthened in real-time streaming services.

### Mobile P2P node scheduling policies

Unlike peers generally connected to wired networks, mobile nodes have diverse various constraint characteristics in software environments, types of network, service bandwidths, recall time, cache performance, network interface, and mobility. Due to these characteristic, the churning phenomenon frequently occurs in the network. Churning refers to the phenomenon in which joining and withdrawals frequently occur on the network in service due to the mobility of nodes and the restriction on available resources. Therefore, frequent churning becomes a cause of reduction in network efficiency, so that QOS cannot be guaranteed [12]. One of the measures to solve this problem is the Relay Join Strategy [4]. This method is divided into a network join strategy and a pre-caching strategy. Figures 3-1 and 3-2 show the outlines of the existing network join tree and the relay join strategy tree, respectively. In the network join tree shown in Figure 3-1, when the parent node a has been churned, the child nodes (node b, node c, and node d) start to execute the scheduling to join a new parent node, causing thus loads to the network. However, in the Relay Join Strategy shown in Figure 3-2, changes in the network are not large, because only child node b should newly join.

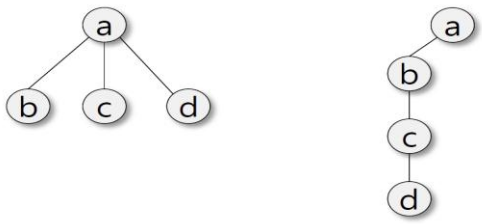


**Figure 3-1** Conventional Join **Figure 3-2** Relay Join Strategy

## EXTENDED PEER MANAGEMENT STRATEGIES

### Degree Ordered Strategy

In the cases when a node wishes to participate in the service joined on a wired P2P network, the TOT or the BOT method may distort the tree leading to imbalance, thereby causing encumbrance to the operation of the network. Therefore, to prevent the distortion of the network tree, a measure to stably manage the number of nodes being updated even when a node drop-out or participation has occurred in any position in the tree is necessary. The Degree Ordered Strategy (DOS) can be said to be a policy that minimize the value calculated using Eq. (3.2) when there are brother nodes $k$ belonging to the same degree and the number of the child nodes $KT_i$ of the sub tree, of which the parent is brother node $k_i$, is assumed to be and the total average of the child nodes belonging to individual sub-trees is assumed to be as shown in Eq. (3.1).

$$KT_{iAVE} = \sum_{i=1}^{k}(KT_i)/k \quad (3.1)$$

$$\sum_{i=1}^{k}(KT_i - KT_{iAVE})^2/(k-1) \quad (3.2)$$

That is, minimizing Eq. (3.2) means that the numbers of child nodes belonging to individual sub trees are evenly set so that a balanced tree can be formed.

Stage 1: When the root node in the relevant tree $T_i$ is assumed to be $R_i$, the node $N$ that wishes to participates searches the leaf node $L_i$ that has the lowest degree ($degree_{R_i \to n}$), the widest bandwidth($rate_{R_i \to n}$), and fewest brother nodes ($bro_{R_i \to n}$) (see Eq. (4)).

$$max_{\ L_i \in t} \left(\frac{rate_{R_i \to n}}{degree_{R_i \to n}}\right) .AND. \ \ min_{\ L_i \in t}\ (bro_{\ with\ R_i}) \quad (4)$$

Stage 2: The parent node $P_i$ of the searched node $L_i$ is inspected. If the node $P_i$ has a bandwidth that can provide service, the node will be allowed to join a brother node of $L_i$ and if not, the node will be allowed to join a child node of $L_i$.

Figure 4 shows the concepts of trees for the Bandwidth-Ordered-Tree (BOT), the Time-Ordered-Tree (TOT), and the Degree Ordered Strategy (DOS). When node b has failed on the network, the degrees and the numbers of child nodes affected by the failure in the subtrees become degree 2 five child nodes, degree 1 five child nodes, and degree 1 three child nodes, respectively. Eventually, when the number of child nodes affected by the leaving of one node is large or severely changed, the network will be burdened and will eventually affect the QOS of the P2P network.

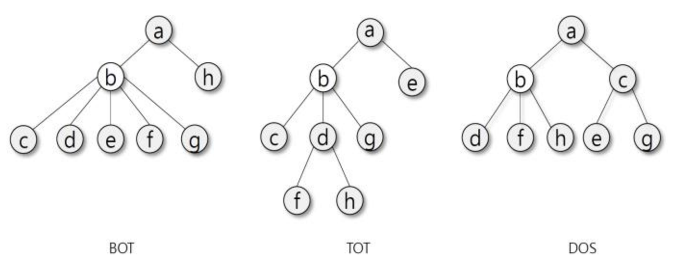


**Figure 4.** Comparison of concept trees

**Mobile P2P Service Strategy**

When a mobile node has participated in a P2P service, the mobile P2P should accommodate all of the characteristics of the terminal, environment, and features of multimedia contents services. Therefore, due to the ranges of movements and services and the limited processing capability of the device, service policies for mobile P2P nodes should be different from those for wired P2P nodes. For instance, whereas nodes that have joined the same P2P session for longer periods of time were judged to be more reliable in the case of wired P2P, mobile devices that have joined the same P2P session for longer periods of time can be said to be more likely to leave the relevant P2P tree due to the limits of battery capacity and available resources. In addition, the network efficiency may drop because peer reallocations occur frequently due to the factors such as available bandwidths and wireless traffic costs. In the case of the existing Relay Join Strategy (RJS), a phenomenon of excessive increases in the degree may occur in cases where service needs flood according to the preference and popularity of contents. In addition, since it was proposed for mobile P2P services, it is not suitable for application to wire / wireless integrated P2P networks. In the case of Time-Ordered-Tree (TOT), if the candidate group is formed only with the time priority index, the performance of the entire system cannot be guaranteed, as the bandwidth between the parent node and the child node and device characteristics on the P2P network can be overlooked. The Mobile P2P Service Strategy proposed in the present can effective configure trees by changing the scheduling factors to fit the characteristics of the candidate node in cases where a node has newly joined the tree. That is, candidate nodes are scheduled first considering the temporal factor, which is the time during which the candidate node stayed in the network. In the cases where the candidate nodes are wired nodes, the loyalty of the nodes, which is the time during which the candidate nodes stayed in the network is considered and in the case of mobile nodes, the node that participated in the network the most recently becomes the candidate node considering the available energy or transmission costs of the nodes and the frequent churning phenomenon due to the deadlines for use of the relevant contents. Thereafter, the bandwidths in which messages can be transmitted to the candidate nodes and traffic costs are calculated to investigate whether the child node can enter or not and the parent node is finally selected. Table 1 shows the score calculation algorithm that determines the order of candidate nodes according to wired and mobile environments; Table 2 shows the parent node selection algorithm.

**Table 1.** Scoring algorithm to determine candidate ranking

```
Algorithm  CandidateRanking();
/*
for node [i]
score[] (Array of score for candidate ranking),
abw[] (Array of Available bandwidth ),
cot[] (Array of Transmission cost), curt (Current time),
ijt[] (Array of Joined time),
tfac[] (Array of Time factor)
*/
Begin
i=0;
while(Nodes[i] = true) {
if (Nodes[i] = WireLineNode)
tfat[i] = curt – ijt[i];
else
tfat[i] = 1 / (curt – ijt[i]);
score[i] = tfat[i](abw[i] / cot[i]);
i++;
}
```

**Table 2.** Parent Node Selection Algorithm

```
Algorithm : ParentNodeSelection()
/*
                    for CandidateNode[i]
ChdAva[] (Array of Joinable Index (> 1)),
WT (The traffic cost weight, the mobile node is 0.1≤ wt ≤ 1 and the other is 1),
MaxBW[] (Array of Maximum available bandwidth),
jReqBW[] (Array of Sum of newly requested child node bandwidth)
      jServBW[] (Array of Sum of child node bandwidths currently receiving service) */
Begin
while(true) {
if (MAX ( Score[] ) >0 )
j = Index of MAX ( Score[] );
else
bleak;
if (j > −1)
ChdAva[j]= (WT × MaxBW[j]) / ( jReqBW[j] + jServBW[j] );
else
break;
if (ChdAva[j] > 1)
ParentNode = j;
else
Score[j]=0;
}
```

## EXPERIMENT AND PERFORMANCE EVALUATION

### Performance analysis environment

For the P2P network environment, 3,600 nodes with different bandwidths were created. The service arrival rate is 1 / sec and follows the λ (Poisson distribution). Here, 50% was set as mobile nodes and the top was connected to the mobile super node. The available bandwidths, transmission costs, and times of stay in the system of individual nodes were assumed to follow the log-normal distribution. The video running time was set to 600 sec and it was decided that the mobile nodes should unconditionally leave the session after the time to receive the stream service (600 sec).

### Network overhead due to peer errors

If a peer serving as a parent node in a P2P network leaves the network, the P2P network will suffer node failure and the restoration work will begin again. This work is a process through which the child nodes that have lost their parent search for a new parent node and form new connections and becomes overheads to the operation of the network. Figure 5 shows the numbers of nodes that must be restored as the number of defective nodes increases. When the total number of defective nodes in the network was120, the number of the nodes that had be restored in the case of the BOT and TOT methods were 1,768 and 1,453, respectively, larger than 1,200. The number of nodes that must be restored in the case of the RJS method was 1,001 and this smaller number of nodes that must be restored can be attributed to the fact that the proportion of mobile peers increased in the experimental environment. Therefore, the extended peer management strategy (EPS) proposed in the present paper is more effective than other methods in wired / wireless integrated networks, because the numbers of nodes that must be restored was 803. Specifically, the average number of nodes required for network restoration was 508, 422, 303, and 272 in the case of BOT, TOT, RJS, and EPS methods, respectively.

### Average service delay

With regard to the total delay of the network, the Startup-Latency for joining with the parent node can be added at the beginning, and the service-latency due to the recovery of overall errors of the network, such as load on the network and defects of the parent node can be added while the service is in progress. In addition, the time taken to receive the amount of data that can be played back at the beginning after participating in the network and the delay phenomena that frequently occur during playback are important elements, as they affect the node withdrawal rate in real time streaming services. Figure 6 shows changes in the average service delay time according to individual methods as services progress while increasing the number of nodes in the network. As with the service delay, it can be seen that the latency increases as the network size increases. It can also be seen that the delay is longer in the case of TOT, because the time to obtain data is longer. It can be seen that the average latency of the method proposed in the present paper is better than that of other methods, because the time and bandwidth factors were selected considering the characteristics of wired/wireless nodes.

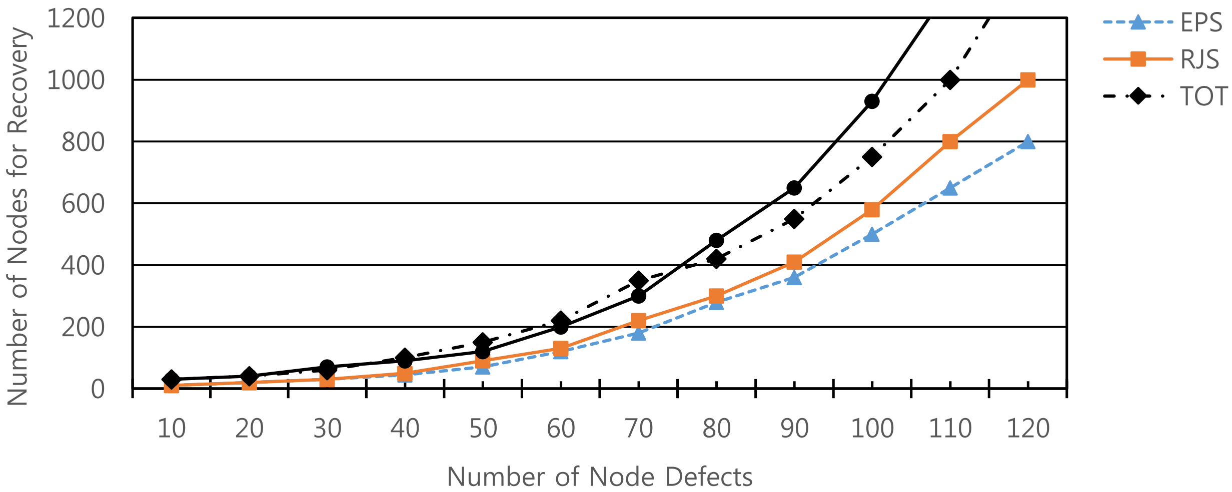


**Figure 5.** Number of Restoration Nodes due to Network Faults

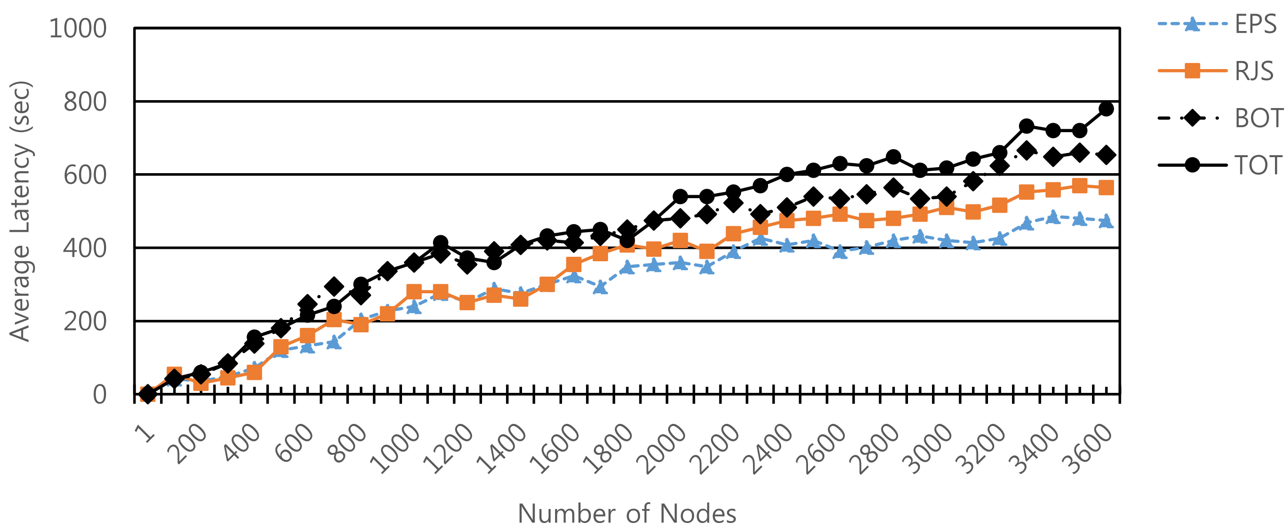


**Figure 6.** Average latency as node increases

## CONCLUSION

While mobile devices have several advantages as compared to PC or server grade nodes in mobility, they are constrained more than those nodes that constitute wired P2P networks in terms of the limit of available resources and temporality. Although diverse mobile devices currently use p2p networks, efficient services cannot be provided with the node scheduling method for existing wired networks, because the constraints in the resources and environments of mobile devices cannot be considered. The present paper proposed an effective peer management policy considering the characteristics of terminals on wired / wireless integrated networks by faithfully implementing the existing P2P concept and considering the characteristics of mobile devices. The policy showed more excellent characteristics than the existing Bandwidth-Ordered Tree (BOT) method, Time-Ordered Tree (TOT) method, and Relay Join Strategy (RJS), which is specialized for mobile nodes.

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