Journal of Digital Contents Society Vol. 14 No. 1 Mar. 2013(pp. 89-95)
http://dx.doi.org/10.9728/dcs.2013.14.1.89

A Locality based Resource Management Scheme for Hierarchical P2P Overlay Network in Ubiquitous Computing

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Abstract

Many peer-to-peer (p2p) systems have been studied in distributed, ubiquitous computing environments. Distributed hash table (DHT)-based p2p systems can improve load-balancing even though locality utilization and user mobility are not guaranteed. We propose a mobile locality-based hierarchical p2p overlay network (MLH-Net) to address locality problems without any other services. MLH-Net utilizes mobility features in a mobile environment. MLH-Net is constructed as two layers, an upper layer formed with super-nodes and a lower layer formed with normal-nodes. The simulation results demonstrate that MLH-Net can decrease discovery routing hops by 13% compared with JXTA and 69% compared with Chord. It can decrease the discovery routing distance by 17% compared with JXTA and 83% compared with Chord depending on the environment.

Keywords : DHT, Locality, Mobile, P2P, Resource Management, Ubiquitous computing

계층적 P2P에서의 근거리 기반 효율적 자원관리 기법

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요 약

유비쿼터스 분야에서는 다양한 형태의 P2P 시스템을 분산환경을 위하여 연구하고 있다. 분산해쉬테이블(DHT)기반의 P2P 시스템은 부하조절을 통한 효율적 기법으로 제시되고 있는 반면 이동성과 근거리 기반의 자원 활용을 보장하지는 못하는 문제점을 가지고 있다. 본 연구에서는 이를 극복하기 위하여 이동상황에서의 근거리 기반 P2P 시스템 (MLH-Net)을 제안한다. 이는 이동성에 기반하여 두 개의 계층으로 이루어져 있다. 상위 계층의 경우 super node를 통한 전체적인 관리를 담당하며, 하위 계층의 경우 일반 노드의 망으로 구성되어 있다. 제시하는 방법을 종래의 JXTA 및 Chord 와 비교 실험 한 결과 node의 발견 시 메시지 이동 hop은 JXTA 대비 13% 및 Chord 대비 69% 감소되었으며, 네트워크 거리의 경우도 각각 17% 및 83% 감소되는 효과를 확인 하였다.

키워드 : DHT, 근거리, 이동성, P2P, 자원관리, 유비쿼터스 컴퓨팅

1. Introduction

In a mobile environment, there are limitations: limited power supply, smaller user interface, limited computing power, limited bandwidth and limited storage space; and above limitations must be considered for deploying a p2p overlay network. Locality and mobility are important factors as well as the limitations in a mobile environment. This paper is motivated to address locality problem and to support mobility in a mobile p2p environment. In this paper, we propose a

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▣ 이 논문은 2012년도 정부(교육과학기술부)의 재원으로 한국연구재단의 지원을 받아 수행된 연구임(No. 2012R1A1A2043400).

mobile locality-based hierarchical p2p overlay network, called MLH-Net. It is based on the p2p overlay network of JXTA. MLH-Net is motivated to address locality problems without other external services, to provide load-balancing of DHT simultaneously, and to support mobility. In a mobile environment, there are major limitations such as limited power, computing capability, bandwidth, storage space, and an insufficient user interface. To deploy a p2p overlay network in a mobile environment, these limitations should be considered. In particular, we have considered mobility and locality as important features. MLH-Net addresses the locality problem by using mobility without any other external services such as GPS. Second, we provide a recovery mechanism within a given p2p overlay network to support mobility because the p2p overlay network should be dynamically reconfigured. Finally, we propose a locality-based list of super-nodes to provide locality-based discovery. Because the MLH-Net guarantees one hop during the locality-based discovery process, simulation results show that our p2p system can decrease discovery routing hops by 13% compared with JXTA and 69% compared with Chord. It can decrease discovery routing distance by 17% compared with JXTA and 83% compared with Chord depending on any given environment.

The rest of this paper is organized as follows: Section 2 describes related p2p systems for improving locality, Section 3 describes the proposed architecture, Section 4 describes the evaluation, and Section 5 describes the conclusion.

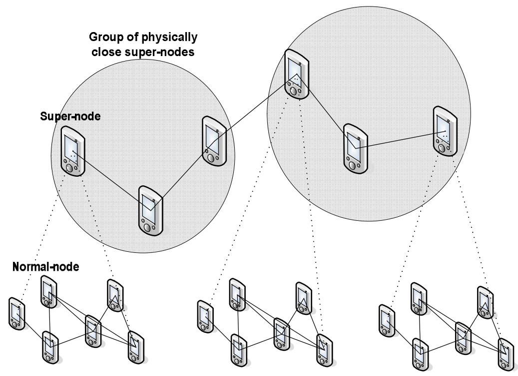
2. Related Work

Unstructured p2p systems such as Gnutella [1], Napster [2], and Freenet [3] are p2p file sharing systems. Gnutella uses a flooding mechanism to find a resource or a node without a central organization; Napster is a hybrid p2p system using a central server; and Freenet is a pure p2p system. But, these systems have scalability problem. To address scalability problem, DHT-based p2p systems such as Pastry [4], Tapestry [5], Chord [6], CAN [7], and JXTA [11] [12] [13] [14] [15] have emerged. Pastry, Tapestry, and Chord are ring-based p2p systems and Can is based on a virtual n-dimensional Cartesian coordinate space. These DHT-based p2p systems have goals: support self-organizing without a centralized structure and improve load-balancing by using discovery and routing mechanisms. These systems also distribute resources or services over a p2p overlay network by using a hash function such as SHA-1. This can reduce lookup latency. And a generalized scheme to build an efficient P2P system is introduced in [16].

Although DHT-based p2p systems distribute resources uniformly among nodes for improving load-balancing, they have locality problem. That means DHT-based p2p systems cannot support locality-based discovery with considering user mobility in a mobile environment. Because most queries are sent through the overall p2p overlay network, there are some disadvantages such as increased response time and increased bandwidth usage. To address locality problem, p2p systems such as Graps [8], SkipNet [9] and Brocade [10] have emerged. In SkipNet, they limited the storing position of resource and proposed a locality-based routing mechanism. Because the locality information is stored into the resource name, it is not physical location-based locality but logical location-based locality. Skip List and the routing mechanism also increase complexity. In Graps, they proposed a hierarchical virtual network to support lookup services. The hierarchical virtual network consists of sub-networks, which consist of physically close nodes, and a super-network, which consist of the leaders of each sub-network. But, resources and nodes increase in a sub-network and then the leader of that sub-network sacrifices load-balancing in a super-network. Our goal is to deploy a p2p overlay network for improving locality in a mobile environment. But, these systems cannot support both locality and mobility.

3. Proposed Architecture

In this section, we overview the proposed p2p system, a mobile locality-based hierarchical p2p overlay network. Specifically, its structure and management mechanism are explained. MLH-Net is constructed as two layers, i.e., the upper layer and the lower layer. The upper layer is configured with super-nodes and the lower layer is configured with normal-nodes, where each normal-node is connected to its associated super-node.



(Figure 1) An example of the proposed p2p system

An example of the proposed p2p system, as shown in (Figure 1), shows the basic structure of MLH-Net. As in (Figure 1), a super-node is connected to a group of normal-nodes, which are connected to each other. When a normal-node needs to identify some specific resources, a discovery query is propagated through the upper layer. If this request can be serviced by any specific target, which is physically close to itself, propagating this query may waste network bandwidth and cause unnecessary traffic. The main goal of MLH-Net is to prevent a discovery query from being propagated through the overall p2p overlay network and thus to guarantee a physically short distance between requestor and target. To achieve this goal, a group of physically close super-nodes is constructed for efficient management. The mechanism for this group will be discussed in the next section.

3.1 Introduction of the PCSN-List

For the upper layer configuration of MLH-Net, a physically close super-nodes list (PCSN-List) is specified to be a set of information about physically close super-nodes in a p2p overlay network. The PCSN-List is configured with two sub-lists, i.e., within max-hop super-nodes list (WMSN-List) and out of max-hop super-nodes list (OMSN-List). The max-hop is the maximum hop value over a p2p overlay network as a standard value to determine whether super-node data are maintained in the WMSN-List or in the OMSN-List. Those super-nodes, whose hop values are equal to or less than the max-hop value of a PCSN-List owner, can be maintained in the WMSN-List.

<Table 1> The data structure of PCSN-List

PCSN-List				
WMSN-List	bExtend	array of super-node	OMSN-List	array of super-node

<Table 2> The data structure of a super-node

super-node	name	identifier	IP address	hop	max-hop	t-stamp

The data structure of PCSN-List and its associated super node is shown in <Table 1 and 2>. WMSN-List is the list of super-nodes that are physically close to the owner for sharing resources, formed as two fields, ‘bExtend’ and an array of super-nodes, which are constructed as 6 fields as shown in <Table 2>. OMSN-List is the list of super-nodes that are physically close to the owner but cannot be maintained in the WMSN-List for the same purpose, formed as one field which is an array of super-nodes. Data fields in <Table 2> are formed to be the minimum information about physically close super-nodes required to configure the PCSN-List for efficient resource sharing between super-nodes. The ‘bExtend’ in <Table 1> refers to whether the WMSN-List is full or not. WMSN-List can be extended to its limit continuously. So, if the WMSN-List cannot be extended anymore, the ‘bExtend’ value is set for false. The ‘name’ denotes the name of a super-node, ‘identifier’ is a unique identification value in a p2p overlay network, ‘IP address’ is the IP address of a super-node, ‘hop’ is an overlay network hop value between super-nodes, ‘max-hop’ is an overlay network boundary value, and ‘time stamp’ is the last updating time of a super-node data. In <Table 2>, the hop value refers to an overlay network hop value from the PCSN-List owner to another super-node in the PCSN-List.

3.2 PCSN-List Management Scheme

To manage the PCSN-List, we need to determine the extension point for the PCSN-List. One metric to measure the PCSN-List extension point, called PEP, is used to determine whether a super-node can maintain more super-nodes in its own WMSN-List or not.

$$\mathrm{PEP} = \left(11 - \left\lceil \frac{\mathrm{CP}}{10} \right\rceil\right) * \mathrm{SH} * \mathrm{W}$$

Computer power (CP) shows the processing ability of a super-node and it can be represented from one to 100. Also the sum of hops (SH) shows the sum of hops for all super-nodes only in the WMSN-List. W is a weight value to control PEP and we set W to one in this paper. We assume that CP can be obtained from a node to show relative performance. If CP is 100 and all super-nodes in the PCSN-List have one hop value, a super-node can maintain a maximum of 100 super-nodes. PEP can be obtained from zero to more than 100. A PEP equation can be derived to represent 100 basis points. If PEP is less than 100, the ‘bExtend’ value is set to true and a super-node can maintain more supernode data in the WMSN-List. Otherwise, if PEP is equal to or greater than 100, the ‘bExtend’ value is set to false and this super-node cannot maintain more supernode data in the WMSN-List, except in some cases. This update changes the data for super-nodes in the PCSN-List. A change in PEP causes the max-hop value to be re-determined along with the ‘bExtend’ value. This process can be specified as follows.

1. Initially, PEP is less than 100,
- *Max-hop is 0 and ‘bExtend’ is true.*

2. When PEP is equal to or greater than 100,
- *Max-hop is determined as the biggest hop of a super-node in WMSN-List and ‘bExtend’ is false.*

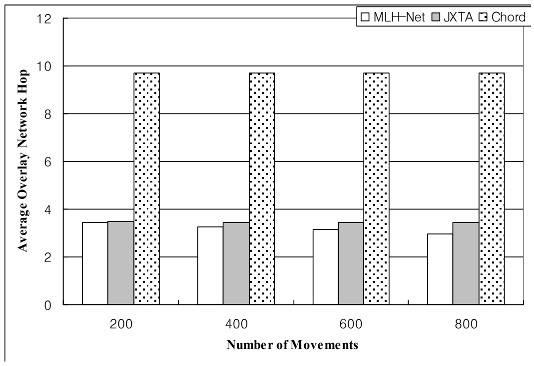
3. New super-node data, which has a hop value that is less than max-hop - 1, is stored on WMSN-List;
- *Super-node data, with the biggest hop or the oldest time stamp in WMSN-List, is removed and moved to OMSN-List. PEP is recalculated.*
- *If the recalculated PEP is less than 100, max-hop is re-determined and ‘bExtend’ is true.*
- *If it is equal to or greater than 100, max-hop is re-determined and ‘bExtend’ is false.*

At the final step, although a super-node may have the 'bExtend' value equal to false, it can receive more data from super-nodes with hop values less than max-hop - 1. This process makes the PCSN-List more localized because a piece of super-node data with the biggest hop value is removed and moved to the OMSN-List. Because this process includes PEP, the number of super-nodes in each PCSN-List may differ. The max-hop value of each PCSN-List may be different and can be changed dynamically. Therefore, each super-node has its own PCSN-List which is centered on itself.

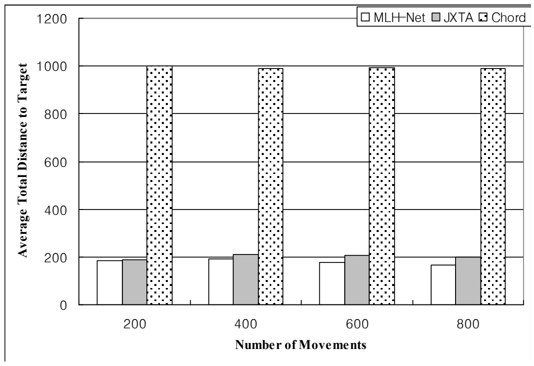
4. Evaluation

In this section, we describe the evaluation result of the proposed architecture compared with the conventional P2P model called JXTA and Chord. In the experiments, when a node moves, a moving node is selected in random order and when a node discovers a resource, the discovering node and its target resource are also selected in random order.

In (Figure 2), the hop value of Chord is 9.7. This is the same in all graphs. The gap between MLH-Net and Chord increases while the number of movements increases because the hop value of MLH-Net decreases. For the last bar case, the hop value of MLH-Net is 2.98. This is a 13% decrease compared with JXTA, which is 3.45 and a 69% decrease compared with Chord, i.e. 9.7.



(Figure 2) Hop for an increasing number of movements



(Figure 3) Average distance for an increasing number of movements

In (Figure 3), the y-axis shows the average total distance to target for any discovery query being propagated. While the number of movements increases, the gap between MLH-Net and Chord increases. For the last bar case, the y-axis value of MLH-Net is 165. This is a 17% decrease compared with that of JXTA, which is 201, and an 83% decrease compared with that of Chord, which is 991.

5. Conclusion

To deploy a p2p overlay network in a mobile environment, we must consider several features of a mobile environment. To provide a mobile p2p system, we propose an

MLH-Net. This is a mobile locality-based p2p overlay network that does not destroy the load-balancing advantage of DHT. MLH-Net uses mobility in a positive manner when the PCSN-List is exchanged and extended. In the experiments, MLH-Net decreases discovery routing hops by 13% compared with JXTA and by 69% compared with Chord. It decreases discovery routing distance by 17% compared with JXTA and by 83% compared with Chord. MLH-Net provides a locality-based discovery mechanism based on PCSN-List being configured by using mobility. It can be deployed in any mobile environment for enhancing locality without any other external services.

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