Available online at www.sciencedirect.com
ScienceDirect
Computer Networks 51 (2007) 1998–2014
Computer Networks
www.elsevier.com/locate/comnet

Georoy: A location-aware enhancement to Viceroy peer-to-peer algorithm ☆

Laura Galluccio [a], Giacomo Morabito [a,*], Sergio Palazzo [a], Marco Pellegrini [b], M. Elena Renda [b], Paolo Santi [b]

[a] *Dipartimento di Ingegneria Informatica e delle Telecomunicazioni, University of Catania, V.le A. Doria 6, 95125 Catania, Italy*
[b] *Istituto di Informatica e Telematica Via G. Moruzzi 1 56124 Pisa, Italy*

Received 5 May 2006; received in revised form 30 August 2006; accepted 28 September 2006
Available online 3 November 2006

Responsible Editor: E. Ekici

Abstract

The success of experiences such as Seattle and Houston Wireless has attracted the attention on the so called *wireless mesh community networks*. These are wireless multihop networks spontaneously deployed by users willing to share communication resources. Due to the *community* spirit characterizing such networks, it is likely that users will be willing to share other resources besides communication resources, such as data, images, music, movies, disk quotas for distributed backup, and so on. To support resource exchange in these wireless mesh community networks, algorithms for efficient retrieval of information are required. In this paper we introduce *Georoy*, an algorithm for the efficient retrieval of the information on resource location based on the *Viceroy* peer-to-peer algorithm. Differently from Viceroy, Georoy exploits the capability of setting and managing a direct mapping between the resource ID and the node which maintains information about its location so as to speed up the search process. Simulation results show that Georoy enables efficient and scalable search of resources and can be successfully used in wireless mesh community networks.

Keywords: Wireless mesh networks; Community networks; Resource localization; Distributed hash tables; Scalability

1. Introduction

Wireless mesh networks are a promising area for the deployment of new wireless communication and networking technologies [4,5].

One of the possible application scenarios for wireless mesh networks is the realization of *wireless community networks*, which are becoming increasingly popular since the advent of cheap wireless technologies such as IEEE 802.11.

☆ The work of L. Galluccio, G. Morabito and S. Palazzo was partially supported by National project Wireless 8O2.16 Multi-antenna mEsh Networks (WOMEN) under grant number 2005093248.
* Corresponding author. Tel.: +39 095 7382355; fax: +39 095 7382397.
E-mail addresses: laura.galluccio@diit.unict.it (L. Galluccio), giacomo.morabito@diit.unict.it (G. Morabito), sergio.palazzo@diit.unict.it (S. Palazzo), marco.pellegrini@cnr.it (M. Pellegrini), m.elena.renda@cnr.it (M.E. Renda), paolo.santi@cnr.it (P. Santi).

1389-1286/$ - see front matter
doi:10.1016/j.comnet.2006.09.017

Given the *community* spirit of such networks, it is expected that users will be willing to share also non-communication resources, such as data, images, music, movies, disk quotas for distributed backup, etc. It is therefore likely that peer-to-peer applications will play a fundamental role in enriching the services offered by community networks.

In this paper we consider one of the major problems to be solved in peer-to-peer applications, i.e., efficiently finding the resources currently available in the network, in the context of wireless mesh community networks. To address this problem, we propose a methodology for resource search in the network which exploits the feature of appropriately mapping the resource ID to the location of the node in the network which possesses information about the location of this resource. This feature can be exploited for performing geographic forwarding of requests and, thus, speed up traditional distributed hash table (DHT) algorithms. Our algorithm, denoted as *Georoy*, is a location-aware enhancement to Viceroy proposed in [12]. To the best of our knowledge, Viceroy is the only DHT algorithm proposed in the literature which provably ensures a good balance of the load generated by search requests among the peers composing the network. Since load balancing is essential to guarantee adequate performances in wireless mesh networks, we believe Viceroy is a good starting point for implementing efficient and scalable resource sharing in this scenario.

The emphasis in our design is on *scalability*, since we believe this will be a fundamental property of any solution tailored to wireless community networks. In fact, the coverage area of community networks is expected to increase up to an entire city area, and we envision that the number of nodes composing the network will grow as well, up to hundreds or even thousands of nodes.

In the following sections we describe the Georoy algorithm and we formally prove that the set of logical links created by Georoy efficiently exploits the underlying physical wireless network. Finally, we verify through simulation that the search efficiency of Georoy (i.e., the average number of network-layer messages generated to satisfy a resource request) is as much as seven times better than that achieved by Viceroy, and that it can be successfully used to perform efficient and scalable resource localization in wireless mesh community networks.

The rest of this paper is organized as follows. In Section 2, we present related work, and we highlight the original contributions of our paper. In Section 3 we present the Georoy algorithm. In Section 4, we describe the mobility management procedures for integrating Georoy into a realistic system, and in Section 5 we present a simulation-based performance evaluation of our peer-to-peer resource sharing platform. Finally, Section 6 concludes the paper and discusses future research directions.

2. Related work and basic idea

The problem of enabling efficient peer-to-peer (P2P) resource sharing has been widely studied in the literature, following the success of the Napster file sharing application [13]. Indeed Napster cannot be considered as a pure P2P approach, since the index of the files available in the network is maintained by a centralized server: when a new peer joins the network, it provides the catalog of the files it will to share to the centralized server, which handles also all the search requests issued by peers. Since the use of a centralized server creates a bottleneck (and unique point of failure) in the system, several later proposals adopted a distributed approach to solve the P2P resource sharing problem.

Gnutella v0.4 [1] is an example of flat, unstructured P2P network with no directory service: when a new peer joins Gnutella, it establishes a number of virtual links to other peers in the network according to a certain rule, thus forming an overlay network. When a peer receives (or issues) a search request, it first checks whether the request can be satisfied locally, otherwise it forwards the request to its neighbors in the overlay. The request is flooded in the network until its time to live (TTL) expires. Thanks to its fully distributed nature, Gnutella v0.4 displays better robustness than Napster, but the use of (limited) request flooding causes a considerable message overhead and reduces the accuracy of the search process.

In order to maintain the search efficiency provided by a directory service while not sacrificing robustness and scalability, a number of P2P approaches based on a hierarchical organization of peers have been proposed: network members are divided into a large number of peers that provide content (called *leaf peers* LPs), and into a smaller number of peers that implement local directory services and route search requests (called *super peers* SPs). In hierarchical P2P networks, each super peer provides a centralized directory service to a subset of the leaf peers. Leaf peers are connected to one