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2P-Lookup: Popularity and Proximity based P2P Lookup mechanism over MANETs

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ABSTRACT

With the emergence of P2P applications and mobile devices, users express the need of exchanging data anywhere, anytime. This encouraged the deployment of P2P applications on mobile environment. In resource sharing applications over mobile ad hoc networks, resource search mechanisms reveal new challenges because of the mismatch between the P2P overlay and the MANET underlay and the critical constraints of MANET nodes (high mobility and energy limitation). In this paper, we propose 2P-Lookup, a Popularity and Proximity based P2P Lookup mechanism over MANETs. Our mechanism is composed of two main steps: in the first one, we propose a cross-layer optimization which consists in building the P2P overlay based on physical proximity of peers in order to reduce the mismatch between the overlay and the MANET topologies. This optimization likely matches between overlay and underlay paths which consequently reduces the search delay, increases the success rate, reduces communication redundancy and unnecessary network traffic. In the second step, we focus on the search query routing and we propose a resource popularity-biased random walk to efficiently guide the search query and control its propagation. Our biased random walk optimization further reduces the network traffic without influencing the search success rate. Simulation results show that 2P-Lookup is efficient in a MANET underlay and have better search performances comparing to other related works.

1. Introduction

Peer-To-Peer concept (or P2P) appeared in the Internet to resolve the centralization issue of the client/server concept. The idea is to virtually connect entities called peers in order to form an overlay and exchange information without using a centralized entity. The P2P paradigm has been firstly used for file-sharing applications such as Napster (Napster, 1999) and Gnutella (Matei et al., 2002) which allow users to share and download resources. After that, it has been used for many other applications such as streaming and distributed computing. P2P was firstly deployed on top of fixed underlays such as Internet. In parallel, mobile underlays have been appeared and have gained ground. An example of mobile underlays is Mobile Ad-hoc NETworks (or MANETs) which is composed of a set of mobile devices that directly communicate between them through wireless interfaces without using any infrastructure.

With the emergence of P2P resource sharing applications and mobile devices, users express the need of exchanging information in a spontaneous way (i.e. anywhere, anytime) especially where there is communities of pedestrian users (i.e. with low mobility speed) which share same interests such as sharing scientific papers during conferences, sharing courses in classrooms and libraries, sharing music during concerts, and sharing e-books in public gardens. This phenomenon encouraged the deployment of P2P applications on mobile networks. In resource sharing applications over mobile ad-hoc networks, resource search mechanisms reveal new challenges because the system is composed of two different topologies which act separately from each others. The overlay topology is formed by virtual links between peers and the underlay topology is formed by physical links between mobile devices. If the overlay is unstructured, resource search mechanism performs a double flooding-based routing that generates communication redundancy and unnecessary network traffic. Moreover, existing mechanisms were designed for fixed networks and have poor performances over MANET underlay due to its critical constraints such as high mobility and energy limitation of nodes. To cope with all these challenges, a need to design efficient resource search mechanisms over MANETs becomes evident.

In this paper, we propose 2P-Lookup, a cross-layer popularity and proximity based P2P lookup mechanism over MANETs. Our mechanism is composed of two main steps: In the first one, we propose a cross-layer optimization which consists in building the

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P2P overlay based on physical proximity of peers in order to reduce the mismatch between the overlay and the MANET topologies. This optimization likely-matches between overlay and underlay paths which consequently reduces the search delay, communication redundancy and unnecessary network traffic. In the second step, we focus on the search query routing and we propose a resource popularity-biased random walk to efficiently guide the search query and control its propagation. Our biased random walk optimization further reduces the network traffic without influencing the search success rate.

The rest of the paper is organized as follows: Section 2 presents the background of our work, Section 3 presents the related work, Section 4 presents our P2P search mechanism, Section 5 presents the performance evaluation of our proposal and finally Section 6 concludes the paper.

2. Background

2.1. P2P overlay architectures

A P2P overlay is formed following one of three main architectures as illustrated in Fig. 1:

- *Centralized architecture*: In this architecture, all peers are connected to a server which indexes the information about peers and their shared resources. If a peer wants to locate a resource, it contacts the server to get providers of the requested resource. This architecture facilitates the search procedure and improves the search latency, but the server is the single point of failure in the system. If it stops, the whole system stops.
- *Decentralized architecture*: This architecture is completely distributed and peers locate resources by contacting each other's without using any server. This architecture can be structured or unstructured. In the unstructured architecture, joining peers are blind and connect with the other peers in a spontaneous fashion or according to their local knowledge about the overlay. Flooding-based approaches (Matei et al., 2002; Lv et al., 2002; Gkantsidis et al., 2004) are used to locate resources. In the structured architecture, peers are connected according to defined topologies such as ring or star and information about resources are distributed in a specific way. Distributed hash table approaches such as in Rowstron and Druschel (2001), Zhao et al. (2001), Stoica et al. (2001), and Maymounkov and Mazieres (2002) are used to locate resources.
- *Hybrid architecture*: This architecture is a combination between the centralized and the decentralized architectures and a new concept called super-peer is introduced. Each super-peer which is also a peer is responsible for a set of peers which are attached to it and indexes their resources. The architecture between the super-peer and its peers is centralized and the architecture between super-peers is decentralized.

2.2. P2P resource search mechanisms in fixed networks

P2P overlays have been firstly deployed on a fixed underlay such as Internet and this is what we call "Fixed P2P networks" in this paper. Several resource search mechanisms have been proposed for fixed P2P networks. We briefly describe and classify them into categories (see Fig. 2):

- Blind search methods are proposed for decentralized unstructured overlays where peers are autonomous and have no knowledge about shared resources in the overlay. To locate resources, different approaches can be used such as flooding (Matei et al., 2002) which consists in sending the resource's query to all overlay neighbors which do the same with their neighbors until the resource is found or the Time To Live (TTL) expires. Flooding has a good success rate but it generates a significant overhead in the network. There are many alternatives solutions to control flooding such as Expanding Ring Search (ERS) (Lv et al., 2002) which consists in sending the query with a progressive TTL until the resource is found and random walk search (Gkantsidis et al., 2004) which functions as follows: assuming that a peer has n neighbors, it randomly sends a search query to k neighbors among its n neighbors

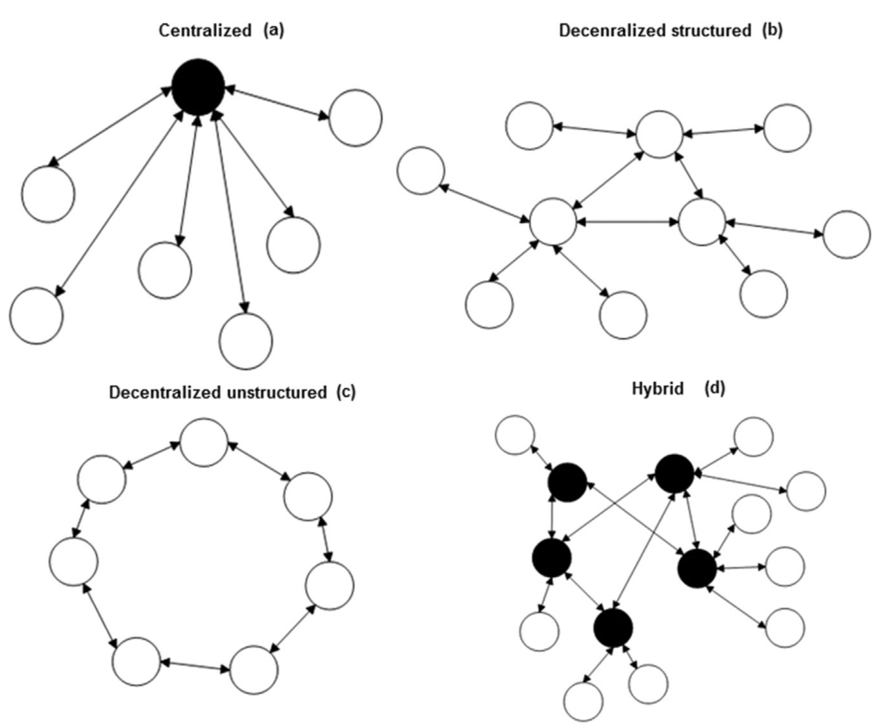

Fig. 1. Main P2P overlay architectures.