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Locality-Awareness and Replication for an Adaptive CHORD to MANet

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ABSTRACT

Structured peer-to-peer (P2P) systems have shown over time a high performance to P2P users. They are typically applied on Internet and wired networks. On the other hand, the evolution of mobile devices and the popularity of infrastructure-less wireless networks as mobile ad-hoc networks (MANET), make of them an interesting underlay for P2P overlays. However, their energy consumption stills a critical element with limited-energy batteries, and the most principal cause of energy consumption is the immense overhead. The aim of this work is to apply the Chord protocol on MANET underlay, in order to benefit from the efficient content-sharing process and the infrastructure-less mobility. At the same time, this work aims to conserve a good level of energy consumption and network lifetime. Therefore, it proposes a novel mechanism of locality awareness and replication of data that attempts to improve the lookup efficiency and reduce the traffic overhead.

KEYWORDS

Distributed Hash Table, Energy, Locality Awareness, Mobile Network, Replication, Structured P2P Systems

INTRODUCTION

The evolution of mobile devices in term of storage memory, processing capacity and other richer functionalities offer them a great popularity. They are used in different domains not limited to call phones and text messages, but also for the access to internet via Wi-Fi, 3G, 3.5G, 3.9G, 4G, etc. However, those infrastructure communications are not always available because of the expensive cost and the longtime of infrastructure installation. Also, they may not be found in some environments like university campus, music concerts and military areas. These limits lead to the well-known of infrastructure-less wireless networks like mobile ad-hoc networks (MANETs), where mobile devices can communicate via Wi-Fi or Bluetooth with no infrastructure.

On the other side, there is the great success of peer-to-peer (P2P) overlay networks in distributed systems, especially for resource-sharing applications. Unlike client-server paradigm, in P2P each peer can share or retrieve data through the network with no centralized control. The first architecture of P2P is the unstructured one (e.g. Napster (Fanning & Parker, 1999)) which provides a random distribution of nodes and flooding-based routing. The second architecture is the structured one with a well-defined overlay topology and a specific routing mechanism, where most of its protocols are based on distributed hash tables (DHT).

DHT is based on a hash function (e.g. SHA-1) to define a unique identifier for each node (called *ID*) and for each resource (called *key*). According to these identifiers, nodes will be placed in the

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overlay topology (ring, tree…) and each resource will be stored on the corresponding node. Hence, DHT systems improve the topology organization and provide an efficient routing between peers by eliminating the flooding.

Recently, there are an increasing attention about deploying P2P overlay on mobile networks in general and on MANET in particular (Al Mojamed & Kolberg, 2015; Da Hora et al., 2009; Lee & al., 2013; Woungang et al., 2015). Besides, P2P and MANET share some common characteristics as: (1) fully distributed, where nodes have the same role (client and server at the same time), (2) self-organized face to unpredictable join and leave of nodes (dynamic topology), (3) self-healing against node failures, (4) scalability and routing efficiency are the basic requirements. (Abid & Othman & Shah, 2014; Kuo et al, 2014).

The deployment of P2P on MANET allows them to benefit from mobility and infrastructure-less communication. Also, MANET applications can benefit from the scalability and the resource sharing efficiency of DHT-Based protocols. Besides these advantages, this deployment presents some challenges because of MANET characteristics, like restricted bandwidth, limited energy and dynamic topology. To cope with these features, P2P protocol has to reduce the number of exchanged messages and accelerate the lookup process. Thus, the request can reach the destination node before its leaving, e.g. because of exhausted batteries or node's mobility (Al Mojamed & Kolberg, 2016; Cherbal & Boukerram & Boubetra, 2016; Chowdhury & Kolberg 2012).

One of the well-known problems encountered in DHT-based protocols and particularly in those applied on mobile wireless networks is the mismatch problem. This latter consists on the non-correspondence between underlay neighbors and overlay neighbors. Because of the random definition of IDs, nodes are distributed in the overlay without considering their real physical positions. This mismatch results in redundant traffic and high end-to-end latency. The solution of this problem is called locality awareness, which consists on considering the physical location of each node when defining its ID. However, the approaches that are interested in this solution ignore an important issue which is the excessive overhead generated when determining the node physical position. Hence, it affects the system efficiency and the mobile-network lifetime.

In this paper, authors propose an approach of locality awareness for Chord on MANET. Its aim is to reduce the lookup physical path on the underlay, while avoiding the generation of high traffic overhead. It differs from existing locality-awareness approaches of DHT-based routing on MANET in considering the traffic overhead and the energy consumption of nodes, in order to cope with mobile network characteristics.

However, the lookup request has a physical path over the underlay as well as a logical path over the overlay, which requires taking into consideration the reduction of the logical path. Therefore, in this work, authors also propose a replication technique that consists on replicating data in more than one node. Its aim is to increase data availability by having more than one responsible for each resource, and thus reducing the lookup path by choosing the closest responsible node.

This work differs from the existing works applied on mobile DHT in: (1) interesting in reducing both logical hops and physical hops of a lookup path, (2) considering reducing the energy consumption of nodes, and (3) combining a mechanism of replication with an approach of locality awareness on mobile DHT protocol. However, to the best of our knowledge, this is the first attempt of using locality-awareness and replication to improve the energy consumption in a mobile P2P protocol.

The paper organization is as follows. The next section outlines the problem statement addressed in this work. Then, an overview of existing solutions about locality-awareness and replication is presented. Then, a detailed description of the proposed approaches of both locality-awareness and data replication is provided. Next, we present the performance analysis of the proposed locality-awareness technique. Afterwards, the simulation results that prove the effect provided by the proposed replication mechanism are presented. Finally, the last section concludes the paper.