A Survey on P2P File Sharing Algorithms over MANETs

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***Abstract*- Mobile Ad hoc Networks (MANETs) consist of a collection of wireless mobile devices dynamically forming a temporary network without the use of any existing network infrastructure or centralized administration. File sharing is a popular used application, which has important status in MANETs. File sharing in MANETs is mainly based on Peer-to-Peer (P2P) network. And a P2P file sharing system generally consists of a search algorithm and a file transfer protocol in which search algorithm attracts a lot of attention. In this paper, we overview and analyze the recently researches about file sharing algorithms. We categorize them into four categories: the DHT-based methods, flooding-based methods, advertisement-based methods and social-based methods according to different searching method. We present a comprehensive up to date survey of these methods. Furthermore, we analyze some challenging issues which inspire the future work.**

Keywords- Peer-to-peer Network; Mobile Ad hoc Network; DHT; Flooding; Advertisement; Social Network

I. INTRODUCTION

Mobile ad hoc networks (MANETs) is a mobile, dynamically and self-organizing wireless networks in absence of a fixed infrastructure, which is usually used in emergency environment such as disaster recovery, military battlefields etc. Recent years, the personal mobile devices such as smart phone, PDA, ipad are increasing rapidly. The number of smart-phone users is by 118 million around the world in 2007 [1] and is expected to reach 300 million by 2013 [2]. And with the rapid development in the field of wireless communication technologies, e.g., WLAN, WiMax, 3G, 3.5G and emerging 4G, mobile users now want to have access to applications and data whenever and wherever through mobile handheld devices. The mobile user would like to generate personal content, store useful information, search content from Internet or other mobile devices and share content with their friends all in handheld mobile platforms [3].

However, the limited communication capacity of the base station is not easy to satisfy the big requirement. MANETs consisted by the mobile devices which are sufficient with wireless technologies such as WIFI or Bluetooth, are effective and important supplement to the application between mobile users. The mobile devices bring new application scenario to MANETs. For instance, in a course material (e.g., course sliders, review sheets, assignments) in a school campus or conference, people can share their interesting files. Based on MANETs, mobile users can download ringtones and music files from Internet and share them to their friends, while, many mobile service providers provide Push-To-Talk (PTT) service to their subscribers. File sharing in MANETs attracts more and more researchers' attention.

P2P over MANETs is the most popular used pattern of file sharing within MANETs. P2P system is initiated in the middle of 1990s. P2P system is deployed on the Internet which is formed by creating an overlay network. P2P overlay consists of upper-layer connections among nodes, or peers, which are independent of the underlay or substrate network, abstract peers view of the connections that make up the network. Here the interaction among peers generally appears at network and application level. P2P file sharing network is very widely used in recent Internet. And within MANETs, P2P file sharing approach is also widely adopted.

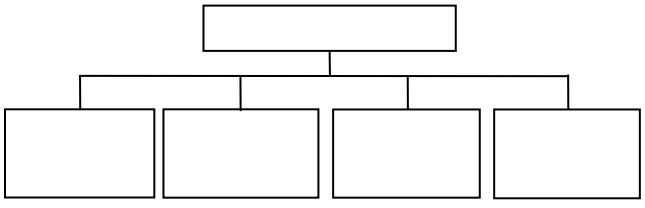

Fig. 1 The Classification of P2P file sharing methods over MANETs

In general, a P2P file sharing system mainly consists two parts: search algorithm and a file transfer protocol. File transfer protocol is responsible to downloading files by use of TCP connection. While search algorithm is responsible for transmitting query messages and searching results. And search algorithm, which has more relationship with efficiency, attracts more attention [4]. A lot of proposal discusses the P2P file sharing on MANETs and we classify them into four kinds according to their varying searching principle: DHT-based method, flooding-based method, advertisement-based method and social-based

methods. The Fig.1 illustrates the classification of the P2P file sharing algorithms over MANET. The target of this paper is to study searching methods used in P2P file sharing system in MANETs and motivate the future work.

The rest of the paper is structured as follows: Section II will briefly introduce the comparison between P2P and MANETs. Section III will present P2P file sharing algorithms over MANETs according the classification respectively. Finally, we conclude the paper and highlight some challenging issues in Section IV.

II. THE COMPARISION BETWEEN P2P AND MANETS

The successful deployment of P2P file sharing system and the impediments to file sharing in large-scale MANETs make the P2P file sharing over MANETs an inevitable developing trend for the promising vision of pervasive file sharing for mobile users. Fig.2 illustrates an example of a P2P overlay on MANETs. The light circles represent nodes participating in the overlay network, while the dark circles are not part of the overlay. The solid lines show how the overlay network is connected, with potentially multiple hops of the underlying MANETs providing the direct overlay connections. The dashed lines represent the MANETs links. In full mobile nodes environment, it is more complex on the construction of the overlay network. And recent works present cross-layer architecture or just use application layer to implement the file sharing.

We notice that there are some similar features for both P2P file sharing network and MANETs. The P2P network and MANETs are both self-organization and decentralization. There is no central server which can manage and coordinate the network. Nodes establish connection to each other spontaneously.

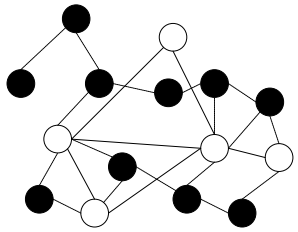

Fig. 2 An example of a P2P overlay running on a MANETs

- The frequently changing topology is another parallel of P2P network and MANETs, although the reason is different. In MANETs, the terminal mobility of the node is the main reason, while it is caused by frequently on and off switching of node in P2P network.

- The flooding or broadcasting is necessary in both networks. The network must be periodically probed the connectivity due to the frequency change topology. Thus it will raise the scalability problem which is of high interest in both areas.

- In both networks, a new participant has to find active member of network. In P2P network, a kind of portal is used while in MANET a special portal is the special frequency range.

- The security and Quality of Service are not easy to solve in both networks.

Despite these similarities, also several differences between P2P and MANETs exist as follows.

- P2P network refers to search protocol on application layer, and MANETs focus on routing protocol on the network layer. The virtually overlay network that created to connect nodes is separated from the physical network in P2P network. In contrast, the logical structure of MANETs generally can be mapped directly to the physical network excepting for using hierarchical structure.

- The function of the intermediate nodes is different. In P2P network, the intermediate nodes are used to setup a connection between two nodes which want to share information. Once the connection established, data transmission will implement directly between the two nodes without requirement of the intermediate nodes. However in MANETs, the intermediate is required not only the establishment of connection, but also the data transmission due to the multi-hop attribute.

- In MANETs, limited resources such as transmission bandwidth, energy, memory and processing power must be taken into consideration. On the contrary, P2P terminals have nearly unlimited resource which is not a big concern.

- Contrary to P2P network in which the nodes are fixed position, the nodes in MANETs are more mobile and the mobility are not easy to predict. Thus the connection in MANET is more difficult to maintain.

The behavior of executing a broadcast is difficult. A P2P network is a single cast network and it only generates a virtual broadcast, which may consist of numerous of single cast messages. Whereas MANETs always performs a physical broadcast.

III. P2P FILE SHARING ALGORITHMS OVER MANETS

According to different searching methods, we classify the P2P file sharing algorithms over MANETs into four categories: DHT-based method, flooding-based method, advertisement-based method and social -based methods. The following of this

paper, we introduce them respectively.

A. DHT-Based Method

Most of approaches such as Pastry [5], Tapestry [6], Chord [7] in structured P2P network are mainly based on Distributed Hash Tables (DHT). DHT-based method use DHT to map objects with corresponding nodes in a distributed fashion using hash functions. DPSR [5] and Ekta [8] are the same as the essence of tightly integrating Pastry with DSR at the network layer. The different between them is that DPSR implements a distributed hash table (DHT) in MANETs, while Ekta does not use the DHT for unicast routing.

LocP2P (Location-assisted P2P) [9] adopts indexing algorithm and distributed hashed table (DHT). In LocP2P, a number of mobile content server nodes manage the information of all mobile nodes in a distributed manner through DHT. The mobile nodes location is set as the major key and object ID are selected as secondary key respectively in DHT. In LocP2P, the mobile nodes location is achieved during they are running other applications such as Facebook or Twitter. This method is effective to save up energy consumption.

Garg design the mobile ad hoc network protocol that enables P2P applications to run on MANET with minimum control overhead and satisfactory throughput trough Bluetooth and implement a prototype [10]. This protocol divides the MANETs into small clusters. Whenever a new mobile node joins the MANET, it will measure the distance to each of the clusters by using number of hops, round trip time as the metric and then becomes the member of the appropriate cluster. After joining the cluster, the mobile node will compute the file index of the files that it wants to share and distribute it among all other nodes in the cluster. Considering the file not available in the same cluster, Distributed Hashing Table (DHT) are used in popular P2P protocols like chord and pastry.

DHT-based searching methods rely on DHT to record the content information of the neighbors. When a node wants to search some content, it firstly resorts to the DHT to achieve the relative information. From this point, DHT-based searching approach is very effective. However, the establishment and maintain of the DHT are not easy due to the dynamic topology. A lot of messages are needed to keep the DHTs renew and consistence, which leads to heavy traffic in the networks.

B. Flooding-Based Method

Flooding-based searching methods are based on broadcasting to implement the search process. When a node wants to search some content, it firstly broadcasts the requirement to its neighbors. Then from the response messages, it can obtain the information which relate to the content owner.

7DS [11] is a P2P data sharing system intending to provide an infrastructure to enable online Web-browsing without a direct connection to the Internet. It is one of the first approaches to port P2P technology to mobile environment and it uses local broadcast transmissions for implementing Web documents sharing among peers without connection to the Internet.

Passive Distributed Indexing (PDI) [12] uses local broadcasting for content searching, and specially sets up content indexes on nodes along the reply path to guide subsequent searching. PDI is a general purpose distributed search service which enables resource-effective searching for file based on simple query. PDI utilizes Building blocks for local broadcast transmission of query, response messages, and caching of query results on every device participating in PDI. By use of building blocks, the need for flooding of query message to the entire network can be eliminated for most application.

ORION [4] is proposed by Klemm et al., which is a special-purpose approach for P2P file sharing tailored to MANET denoted Optimized Routing Independent Overlay Network. ORION operation does not depend on the deployment or support of any MANETs routing protocol. However, it combines application layer tasks with techniques known from AODV routing protocol, simple multicast and broadcast protocol. And the Query message distributed in link-layer flooding is borrowed from the simple multicast and broadcast protocol for MANETs. ORION maintains two kinds of routing table: a response routing table generated in the network layer and a file routing table generated in the application layer, which operates similarly to the routing tables used by AODV. ORION considers and resolves the redundancy problem found in the file routing tables with the aid of a response routing table. It relies that the response routing table contains the node where the target route can be found as the next hop.

Duran et al. present two search schemes which use query message filtering (or gossiping) and adaptive hoc-limited search respectively in order to improve the ORION in [13]. The query message filtering (or gossiping) scheme uses query message filtering and gossiping when performing network wide flooding of query messages. While the adaptive hoc-limited search scheme conducts adaptive hop-limited search with local broadcast transmission.

Sung et al. present a reliable communication method for assuring stable P2P data sharing in MANETs in [14]. The proposal consists of a configuration scheme and a routing scheme. The configuration scheme is responsible for configuring a MANETs without intervention of users through allocating the IPs automatically. The routing scheme is responsible for finding emergency routes in the case of the abrupt disconnection. And it applies two reconnection methods: one is the dynamic-alternate algorithm and the other is the dynamic-recruiting algorithm. However, the routing algorithm needs to create a scanning table as well as a lookup table for augmenting reliability in data sharing services. The scanning table contains the

directly connectable nodes while the loop up table contains the location information of target data. Some features of our routing algorithm are similar to those of ORION.

Hayes et al. present a P2P file sharing application over MANETs environments facilitated by Bluetooth [15]. The application has two operation modes. The first mode introduces exactly the form of interaction of P2P file sharing applications designed for the Internet in order to facilitate user driven searching. The second mode is an automatic search process in complete mobile environment. In order to implementing the application, several modifications are made to Gnutella. Firstly, in peer discovery, blue tooth devices use Service Discovery Protocol (SDP) instead of Ping and Pong packets to allow Gnutella nodes to discover each other. Secondly, in search period, the application uses Query and Query Hit packets to implement the manual search; uses RecRequest and RecResponse packets to implement automatic search. Thirdly, in the file transfer period, it extends the protocol to include FileRequest and FileResponse packets. And these packets perform the same function as the HTTP request and response messages, and can be routed through the network.

The most default in flooding-based methods is the high overhead because of the high amount of duplicated messages. These overhead induces the high congestion due to a high volume of traffic, which is a significant problem in MANETs. In addition, local broadcasting used in some methods cannot guarantee file searching success.

C. Advertisement-Based Methods

Tchakarov and Vaidya present a content location service the Geography-based Content Location Protocol (GCLP), which takes physical location information into consideration in order to provide an efficient content location service to nodes in an ad hoc network [16]. GCLP tries to allow each client to find a nearby server by use of the geographical distance as the distance metric (not number of hops). In GCLP, nodes make use of geographic information to advertise content periodically which are hosting to nodes along several geographical directions.

P2PSI [17] is a hybrid push-and-pull P2P file sharing system over MANETs based on Swarm Intelligence. Each node in P2PSI maintains a pheromone table which records the pheromone intensity on each neighbor like. It relies on two important processes: advertisement (push) process and discovery (pull) process. In advertisement process, each file holder regularly broadcasts an advertisement message in order to inform surrounding nodes about what files are to be shared. Specially, P2PSI adopts Bloom filter for summarizing the list of shared files in order to reduce the message size and communication overhead in this process. The discovery process locates the desired file firstly, and then leaves the pheromone to help subsequent search requests. P2PSI adopts across-layer design architecture. Since P2PSI is based on swarm intelligence, a swarm intelligence-based routing protocol, ARA [18], is adopted to ease the cross-layer design. When a node receives a control message of P2PSI at the application layer, it also reinforces the corresponding pheromone entry of ARA routing table. In this way, each node can learn about routing information when receiving a control message of P2PSI. The cross-layer design can efficiently avoid redundant overhead.

Repantis and Kalogeraki propose a file sharing mechanism in [19]. Nodes use the Bloom filter to build content synopses of their data and then disseminate them adaptively to the most appropriate nodes. Though the advertisement-based method reduces the overhead of flooding-based methods, they still generate high overhead for advertising. Additionally, the methods cannot guarantee the successful searching of file, especially when the routes expire due to node mobility.

With the use of swarm intelligence, Dhurandher et al. propose P2PBA (peer to peer file sharing - Bees algorithm) to optimize search process and provide a far more time efficient and robust sharing mechanism [20]. P2PBA exploits (a) percentage network area scanned and (b) selective file retrieval from a set of file bearing nodes by use of the Bee algorithm. Based on the lines of food search behavior of Honey Bees, it optimizes the search process by selectively going to more promising honey sources and scan through a sizeable area.

Advertisement-based methods also lead to high overhead, and they have low search efficiency because of expired routes caused by transient network connections. Flooding-based methods and advertisement-based methods are fit for the relative stable MANETs. However, in more disconnected MANETs, the two kinds of method are failed due to the large overhead.

D. Social -Based Method

In recent works, Social Network theory has been utilized in routing or content sharing algorithms in MANETs and DTNs [21]. Since the node movement in a social network usually follows a certain pattern, social network based routing algorithms consider node contact frequency, predict future contact possibility, and choose the node with the highest possibility of successfully delivering a packet as the next forwarder in routing. However, these algorithms cannot be directly used for content-based file searching since the destinations are unknown in this service.

The social network possesses three properties [22]. (1) nodes (i.e., people) usually exhibit certain movement patterns (e.g., local gathering, diverse centralities and skewed visiting preferences). (2) Nodes usually come into communities according common interest or property and community members frequently meet each other in the community. (3) Different nodes have different role and only few nodes have higher connectivity with other nodes in a community which is called centrality.

Li and Wu propose a Mobile community-based Pub/Sub scheme (MOPS) [23] to implement the content-based service.

MOPS seeks to utilize long-term neighboring relationship between nodes to construct the community in the DTNs. And the community is defined as a clique of nodes where any neighboring relationship is stronger than an adjustable threshold. In addition, MOPS adapts the pub/sub paradigm which integrates push and pull, to determine the interface known as the push-pull boundary and deploy brokers to bridge the boundary. The brokers propagate interests and collect events by utilizing a unique weighted scheme. Extensive real- and synthetic-trace-driven simulation is made and the results are presented to support the effectiveness of MOPS.

SocialCast [24] is a social-based routing framework, which applies on publish/subscribe fashion. It exploits predictions based on metrics of social interaction such as patterns of movements among communities in order to identifying the best information carriers. In a nutshell, SocialCast exploits forecasting techniques to identify the best carriers which are also used in CAR [9]. Especially, it takes more attention to the receivers' interests, the social ties of people and their consequent predicted movements.

ContentPlace [25] defines social relationship based communities and it assumes that users belong to several different social communities, and automatically learns the time spent by them in each community, which types of data users of each community are interested in, and how spread in communities the data are. By using information, each node calculates a utility value for each encountered object regarding its connected communities and caches these objects in a highest utility value first manner. Specifically, each node, upon making contact with another peer, evaluates the utility of the data the peer is carrying and decides which data to fetch from the peer, in order to maximize the total utility of the data in its own buffer. ContentPlace considers five policies to evaluate the social weight: Most Frequently Visited (MFV), Most Likely Next (MLN), Future(F), Present(P), Uniform social(US) and the simulation provide best results in the Most Likely Next and Future policies.

Qureshi et al. present an adaptive protocol to implement a Mobile Social Network based on P2P content driven communication when end-to-end connectivity is not possible [26]. The proposed protocol considers the information about user's interests, content based data storing and forwarding, and host mobility in a disconnected and delay tolerant MANETs. The authors define a three layer stack in the protocol. The top layer supports the user interface which works as an application layer. Then the middle layer provides support for content driven data dissemination in the form of documents and messages. And the third layer is responsible for data forwarding to distant nodes in a multi-hop manner. In order to unicasting messages from point to a specific point in the network, the protocol considers using Ad hoc on-demand Distance Vector (AODV).

SPOON [27] is novel Social network based P2P content file sharing in mobile ad-hoc Networks. It mainly rely on that it leverages social network properties of both node interest and movement pattern. SPOON consists of three parts: the first part is interest extraction algorithm which derives a node's interests from its files; the second part is community construction algorithm which enables users to efficiently retrieve files using intra- and inter-community communication; the third part is node role assignment algorithm which designates the community coordinator and ambassador. A stable node which tightly connects others in its community is designated as the community coordinator. And the community coordinator will guide intra-community searching. For each foreign community, a node that frequently travels to it is designated as the community ambassador. And the ambassador will guide inter-community searching. SPOON implements interested oriented routing protocol to finish interest-oriented file searching and retrieval scheme. And the process of the SPOON for file sharing is as follows. Firstly, it classifies common-interest and frequently encountered nodes into social communities. Secondly, it considers the frequency a node meets different interests rather than different nodes in routing for enhanced searching success rate. Thirdly, it chooses the highly mobile nodes that travel frequently to foreign communities as ambassadors, thus a query can be directly forwarded to the community of the queried file.

Palazzi and Bujari present a special purpose system for searching and transferring files which based on an application layer overlay network and port a DTN type solution into an infrastructure-less environment like MANETs [28]. They leverage peer mobility to reach data in other disconnected networks which implements a store-delegate-and-forward asynchronous communication model to delegate unaccomplished file download or query tasks to special peers. To improve data transmission performance while reducing communication overhead, they select these special peers by the expectation of encountering them again in future and assign them different download starting point on the file.

TABLE I SOCIAL PROPERTIES USED IN SOCIAL-BASED METHODS

methods	intra-community	inter-community	movement pattern	pub/sub	utility function
MOPS[23]	√	√		√	
SocialCast [24]		√	√	√	
ContentPlace [25		√			
SPOON[27]	√	√		√	
[26][28][29]					√

Considering the important role of the current location of mobile node, Li et al. design a location based social network over the mobile ad hoc networks [29] to implement the file sharing. The social relation is established by the similarities among different users and the similarity is measured by considering the current positions and common interests. Each node only

connects to the nodes that have common interests and nearby positions, while, the contents search is handled by using the social relationships and the contents are only shared to the users who are interested in it in order to reduce the management overhead.

Social-based methods consider the social relationship among the mobile devices users. In disconnected MANETs, the social-based methods implement file sharing according to the meet probability. The users with common interest often meet each other, so the file sharing is usually happened among them. So the social properties are very useful to find the file sources and share the files. Table Ⅰ represents the social properties used in recent social-based methods. Most of these methods use the concepts of community, and consider the intra- and inter- community cooperation. And the pub/sub is usually used in the methods too. [26][28][29] use the utility function which is based on social relationship between mobile nodes. However, in social-based methods, the construction of community is a challenging problem due to the constraint connection of the networks and the frequently node mobility.

IV. CONCLUSIONS

In this paper, we study the recent P2P file sharing methods over MANETs. According to the variant searching principal, the file sharing algorithms are classified into four categories: the DHT-based method, flooding-based method, advertisement-based method and social -based method. We give a brief description to each approach and analyze the properties on each kind of method.

Though a lot of research in the field of P2P file sharing over MANETs has made in recent past, there are many challenge issues to be fodder for future research work. Firstly, a suitable content sharing paradigm must minimize the consumption of network resources and must divide the burden of sharing data equally among the set of nodes by thinking about the topology of the network and giving enough incentives for fair sharing. Furthermore, it must maximize the global capacity of the system by using the ability to have parallel communications in different areas of multi-hop wireless networks. Secondly, content is various and large file sharing such as the multimedia content is required with the rapid development of the wireless communication technology. The large file sharing needs more stable end to end path and long transmission time, which is a challenging problem in the MANETs. Last but not least, more relationship between nodes will be used to promote the file sharing process. More and more mobile devices are carried by people, and the relationship between people represents the relationship between mobile devices. And the social information is more stable which can help to complete the dynamic topology of MANETs. The social network properties are more important roles in the file sharing application which will be the trend in the future research work.

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