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Curiosity and Contact History Based File Dissemination in MANET

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Abstract: Present peer-to-peer (P2P) file dissemination methods in mobile ad hoc networks (MANETs) can be divided into three categories: flooding-based, advertisement-based, and social contact-based. The first two techniques can simply be time consuming and low ability to accommodate when the demand grows higher. They are mainly developed for linked MANETs, in which end-to-end relativity among nodes is preserved. The social contact-based methods adjust to the adaptable nature of disconnected MANETs but fail to regard the social contents of portable nodes, which can be subjugated to advance the file searching effectiveness. In this paper, we suggest a P2P content-based system, namely SPOON, for disconnected MANETs. The system uses an interest extraction algorithm to derive a node's concern from its files for content-based file searching. For competent file searching, SPOON assembles similar-interest nodes that frequently gather with each other as a set. The interest-oriented file searching scheme is projected for high file searching efficiency.

Keywords: Social networks, interest-Oriented, Peer to Peer Content-Based, File Dissemination, Disconnected MANETs.

I. Introduction

Recent years, mobile users interact with each other and share files via an infrastructure formed by geographically distributed base stations. However, users may find themselves in an area without wireless service (e.g., mountain areas and rural areas). Moreover, users may hope to reduce the cost on the expensive infrastructure network data. The P2P file dissemination model makes large-scale networks a blessing instead of a curse, in which nodes share files directly with each other without a centralized server. Wired P2P dissemination systems have already become a popular and successful paradigm for file dissemination among millions of users. The successful deployment of P2P file dissemination systems and the aforementioned impediments to file dissemination in MANETs make the P2P file dissemination over MANETs a promising complement to current infrastructure model to realize pervasive file dissemination for mobile users developed. As the mobile digital devices are carried by people that usually belong to certain social relationships, in this paper, we focus on the P2P file dissemination in a disconnected MANET community consisting of mobile users with social network properties. In such a file dissemination system, nodes meet and exchange requests and files in the format of text, short videos, and voice clips in different interest categories.

In MANETs consisting of digital devices, nodes are constantly moving, forming disconnected MANETs with opportunistic node encountering. MANET is a self-configuring infrastructure less network of mobile devices connected by wireless. Each device in aMANET is free to move independently in any directions, and will therefore change its links to otherdevices frequently. Each must forward traffic unrelated to its own use, and therefore be a router. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. Such networks may operate by themselves or may be connected to the larger Internet. MANETs constantly keep moving; hence, have more challenge for file dissemination. The old methods consist of the flooding based methods, advertisement based methods which have high overhead problems and low file searching efficiency. Such transient network connections have posed a challenge for the development of P2P MANETs.

Traditional methods supporting P2P MANETs are either flooding-based [1]or advertisement-based [5], [7]. The former methods rely on flooding for file searching. However, they lead to high overhead in broadcast. In the latter methods, nodes advertise their available files, build content tables, and forward files according to these tables. But they have low search efficiency because of expired routes in the content tables caused by transient network connections. Also, advertising can lead to high overhead.

Recently, social networks are exploited to facilitate content dissemination/publishing in disconnected MANETs [8], [9], [10], [11]. These methods exploit below property to improve the efficiency of message forwarding:

- (P1) nodes (i.e., people) usually exhibit certain movement patterns (e.g., local gathering, diverse centralities, and skewed visiting preferences).
- (P2) Users usually have a few file interests that they visit frequently and a user's file visit pattern follows a power-law distribution.
- (P3) Users with common interests tend to meet with each other more often than with others.

By leveraging these properties of social networks, we propose Social network-based P2P cOntent-based in disconnected mObile ad hoc Networks (SPOON) with four components:

1. Based on P2, we propose an interest extraction algorithm to derive a node's interests from its files. The interest facilitates queries in content-based file dissemination and other components of SPOON.

2. We refer to a collective of nodes that share common interests and meet frequently as a community. According to P3, a node has high probability to find interested files in its community. If this fails, based on P1, the node can rely on nodes that frequently travel to other communities for file searching. Thus, we propose the community construction algorithm to build communities to enable efficient file retrieval.

3. According to P1, we propose a node role assignment algorithm that takes advantage of node mobility for efficient file searching. The algorithm designates a stable node that has the tightest connections with others in its community as the community coordinator to guide intra community searching. For each known foreign community, a node that frequently travels to it is designated as the community ambassador for intercommunity searching.

4. We propose an interest-oriented file searching and retrieval scheme that utilizes an interest-oriented routing algorithm (IRA) and above three components. Based on P3, IRA selects forwarding node by considering the probability of meeting interest keywords rather than nodes. The file searching scheme has two phases: Intra- and intercommunity searching. In the former, a node first queries nearby nodes, then relies on coordinator to search the entire home community. If it fails, the intercommunity searching uses an ambassador to send the query to a matched foreign community. A discovered file is sent back through the search path or the IRA if the path breaks.

SPOON is novel in that it leverages social network properties of both node interest and movement pattern. First, it classifies common-interest and frequently encountered nodes into social communities. Second, it considers the frequency at which a node meets different interests rather than different nodes in file searching. Third, it chooses stable nodes in a community as coordinators and highly mobile nodes that travel frequently to foreign communities as ambassadors. Such a structure ensures that a query can be forwarded to the community of the queried file quickly. SPOON also incorporates additional strategies for file prefetching, querying-completion and loop-prevention, and node churn consideration to further enhance file searching efficiency.

II. Related Work

A. P2P File dissemination in MANETs

a) Flooding –Based Methods

In flooding-based methods, 7DS [1] is one of the first approaches to port P2P technology to mobile environments. It exploits the mobility of nodes within a geographic area to disseminate web content among neighbors. Passive distributed indexing (PDI) [3] is a general-purpose distributed file searching algorithm. It uses local broadcasting for content searching and sets up content indexes on nodes along the reply path to guide subsequent searching. A special-purpose on-demand file searching and transferring algorithm based on an application layer overlay network. The algorithm transparently aggregates query results from other peers to eliminate redundant routing paths. However, these flooding-based methods produce high overhead due to broadcasting.

b) Advertisement-Based Methods

GCLP for efficient content discovery in location-aware ad hoc networks. It disseminates contents and requests in crossed directions to ensure their encountering. P2PSI [6] combines both advertisement (push) and discovery (pull) processes. It adopts the idea of swarm intelligence by regarding shared files as food sources and routing tables as pheromone. Each file holder regularly broadcasts an advertisement message to inform surrounding nodes about its files. The discovery process locates the desired file and also leaves pheromone to help subsequent search requests. The advertisement-based methods reduce the overhead of flooding-based methods, they still generate high overhead for advertising and cannot guarantee the success of file searching due to node mobility.

c) Social Network –Based Methods

Social networks have been utilized in content dissemination algorithms [8], [9], [10], [11] in opportunistic networks. MOPs provide content-based sub/pub service by utilizing the long-term neighboring relationship between nodes. It groups nodes with frequent contacts and selects nodes that connect different groups as brokers, which are responsible for intercommunity communication. Then, contents and subscriptions are relayed through brokers to reach different communities. SPOON enhances the efficiency of intercommunity search by 1) assigning one ambassador for each known foreign community, which helps to forward a query directly to the destination community, and 2) utilizing stable nodes (coordinator) to receive messages from ambassadors.

Social Cast [9] calculates a node's utility value on an interest based on the node's mobility and co-location with the nodes subscribed to the interest. It publishes contents on an interest to subscribers by forwarding the contents to nodes with the highest utilities on the interest. Content Place [11] defines social relationship-based communities and a set of content caching policies. Specifically, each node calculates a utility value of published data it has met based on the data's destination and its connected communities, and caches the data with the top highest utilities. However, above methods mainly focus on disseminating publications to matched subscribers. Therefore, these methods cannot be applied to file searching directly.

III. Proposed Methodology

A. P2P File dissemination in Disconnected MANETs

We first present trace data analysis to verify the social network properties in a real MANET. A P2P MANET file dissemination system usually consists of 1) a method to represent contents, 2) a node management structure, and 3) a file searching method based on steps 1 and 2. Accordingly, SPOON has three main components: 1) interest extraction, 2) structure construction including community structure and node role assignment, and 3) interest-oriented file searching and retrieval based on components 1 and 2. We then present each component of SPOON.

a) Trace Data Analysis

To validate the correlation between node interests and their contact frequencies, we analyzed the trace from the Haggle project, which contains the encountering records among mobile devices carried by scholars attending the Infocom'06 conference. Some participants completed questionnaires, indicating the conference tracks that they are Interested in.

We used a relatively loose community creation requirement that each node only needs to have a high contact frequency with half of nodes in a community. With a stricter requirement and a more sophisticated clustering method, nodes in the same community would share more interested tracks. Above traces verify the previously observed social properties and support the basis for SPOON that nodes with common interests tend to meet frequently.

b) Interest Extraction

Without loss of generality, we assume that node contents can be classified to different interest categories. It was found that users usually have a few file categories that they query for files frequently in a file dissemination system. Specifically, for the majority of users, 80% of their shared files fall into only 20% of total file categories. Like other file dissemination systems we consider that a node's stored files can reflect its file interests. Thus, SPOON derives the interests of a node from its files.

c) Community Construction

First we derive a node's interests from its files. The interest facilitates queries in content-based file dissemination and other components of SPOON. Collective of nodes that share common interests and meet frequently as a community, which node has high probability to find interested files in its community. If this fails the node can rely on nodes that frequently travel to other communities for file searching. We build the community for efficient file searching.

d) Node Role Assignment

We define community coordinator and ambassador nodes in the social network. A community coordinator is an important and popular node in the community. It keeps indexes of all files in its community. Each community has one ambassador for each known foreign community, which serves as the bridge to the community. The coordinator in a Community maintains the foreign communities and corresponding ambassadors in order to map queries to ambassadors for inter-community searching. The number of ambassadors and coordinators can be adjusted based on the network size and workload in order to avoid overloading these nodes. Since ambassadors and coordinators take more responsibility.

e) Interest-oriented File Searching and Retrieval

In social networks, people usually have a few file interests and their file visit pattern generally follows a certain distribution. Also, people with the same interest tend to contact each other frequently. Thus, interests can be a good guidance for file searching. Considering the relation among node movement pattern, individuals' common interests, and their contact frequencies, we can route file requests to file holders based on nodes' frequencies of meeting different interests. Then, the interest oriented file searching scheme has two steps: intra community and inter-community searching. A node first searches files in its home community. If the coordinator finds that the home community cannot satisfy a request, it launches the inter-community searching and forwards the request to an ambassador that will travel to the foreign community that matches the request's interest.

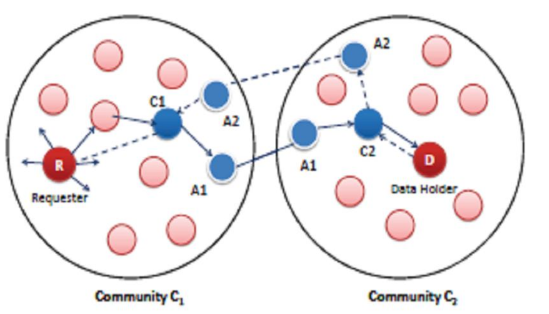

Fig. 1 File searching in SPOON

Fig. 1 depicts the process of file searching, in which a requester (node R) in community C1 generates a file request. Since its neighbors within count hops do not have the file, the request is then forwarded to the community coordinator NC1. NC1 checks the community files indexes but still cannot find the file. It then asks the community ambassador NA1 to forward the request to the foreign community matching the queried file. Using the same way as NC1, the community coordinator NC2 finds the file and sends it back to the requester's community via ambassador NA2. The file is first sent to NC1, and then forwarded to the requester.

B. Information Exchange among Nodes

We summarize the information exchanged among nodes in SPOON. In the community construction phase, two encountered nodes exchange their interest vectors and community vectors, if any, for community construction. In the role assignment phase, nodes broadcast their degree centrality within their communities for coordinator selection. When the coordinator is selected, the coordinator ID is also broadcasted to all nodes in the community. Then, each node reports its contact frequencies with foreign communities to the coordinator for ambassador selection. Besides, when a node meets a coordinator of its community, the node also sends its updated node vector to the coordinator to update the community vector and retrieves the updated community vector from the coordinator. When an ambassador meets the coordinator of its community, it reports the community vectors of foreign communities to the coordinator.

C. Intelligent File Prefetching

Ambassadors in SPOON can meet nodes holding different files since they usually travel between different communities frequently. Taking advantage of this feature, an ambassador can intelligently prefetch popular files outside of its home community. Recall that queries in a local community for a file residing in a remote community are forwarded through the coordinator of the local community. Thus, each coordinator keeps track of the frequency of local queries for remote files and provides the information of popular remote files to each ambassador in its community upon encountering it. When a community ambassador finds that its foreign community neighbors have popular remote files that are frequently requested by its home community members, it stores the files on its memory. The prefetched files can directly serve potential requests in the ambassador's home community, thus reducing the file searching delay.

D. Querying-Completion And Loop prevention

A node can associate a parameter *Smax* with its query to specify the number of files that it wishes to find. A challenge we need to handle is to ensure that the querying process stops when *Smax* matching files are discovered when multi-copy forwarding is used. To solve this problem, we let a query carry *Smax* when it is generated. When a query finds a file that matches the query and is not discovered before, it decreases its *S* by 1. Also, if this query is replicated to another node, *S* is evenly split to the two nodes. A query stops searching files when its *S* equals 0. When a query needs to find more than one file, it is likely that IRA would forward a query to the same node repeatedly. To avoid this phenomenon, SPOON incorporates two strategies. First, the query holder inserts its ID to the query before forwarding the query to the next node. Second, a node records the queries it has received within a certain period time.

E. Node Churn Consideration

In SPOON, when a node joins in the system, it first finds the communities it belongs to and learns the IDs of community coordinators, and then reports its files and utility values to the community coordinator when encountering it. This enables the coordinator to maintain updated information of the community members. A node may leave the system voluntarily when users manually stop the SPOON application on their devices. In this case, a leaving node informs its community coordinator about its departure through IRA. If the leaving node is an ambassador, the coordinator then chooses a new ambassador. If the leaving node is a coordinator, it uses broadcast to notify other community members to select a new coordinator. A node may also leave the system abruptly due to various reasons. Simply relying on the periodical beacon message, a node cannot tell whether a neighbor is left or is just isolated from itself, which is a usual case in MANETs. To handle this problem, each node records the timestamps when it meets other nodes, and sends it to the coordinator through IRA. The coordinator receives this information and updates the most recent timestamp of each node seen by other nodes.

IV. Performance Evaluation

We evaluated the performance of SPOON in comparison with MOPS, PDI+DIS, Cache DTN, Pod Net, and Epidemic. MOPS are a social net-work based content service system. It forms nodes with frequent contacts into a community and selects nodes with frequent contacts with other communities as brokers for inter-community communication. PDI+DIS is a combination of PDI and an advertisement-based DIS-semination method (DIS). PDI provides distributed search service through local broadcasting and builds content tables in nodes along the response path, while DIS let each node disseminate its contents to its neighbors to create content tables. CacheDTN replicate files to network centers in decreasing order of their overall popularity. The Active-CC selects three most active nodes tocollect node contacts and interests when they meet nodes. In Centralized-CC, we purposely let a super node collect all node contacts and interests timely. Both Active-CC and Centralized- CC use AGNES to build communities with the collected information. Since there is no real trace about content sharing in P2PMANETs, we tested in an indirect way. We first conducted the group construction and content distribution as previously described, and then removed the group identity of each node. Then, we run the three methods to create communities. Since there is no real trace about content sharing in P2P MANETs, we tested in an indirect way. We first con-ducted the group construction and content distribution as previously described, and then removed the group identity of each node. Then, we run the three methods to create communities.

V. Conclusion

In this paper we explored a Social network based P2P content file dissemination system in disconnected mobile ad hoc Networks (SPOON). SPOON considers both node interest and contact frequency for efficient file dissemination. We introduce four main components of SPOON: Interest extraction identifies nodes' interests; Community construction builds common-interest nodes with frequent contacts into communities. The node role assignment component exploits nodes with tight connection with community members for intra-community file searching and highly mobile nodes that visit external communities frequently for inter-community file searching; The interest-oriented file searching scheme selects forwarding nodes for queries based on interest similarities. SPOON also incorporates additional strategies for file prefetching, querying-completion and loop-prevention, and node churn consideration to further enhance file searching efficiency.

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