Routing in MANET and P2P Networks: Final Report For Wireless P2P

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June 25 2010

1 Abstract

This paper is mainly about how to apply p2p to MANET network. To reach that goal, we are going to introduce some basic ideas of p2p routing protocol and MANET network, including some recent researches. Then we will explain the mechanism of the four kind of schemas to combine p2p with MANET, a full performance evaluation is also in this paper, including efficiency scalability implementation.

2 Introduction

Since the first appearance of wireless ad hoc networks as the DARPA packet radio networks in the 1970s [1, 2], they became an interesting research object in the computer industry. During the last couple of years tremendous improvements are made in the research of ad hoc networks. The wireless LAN standard 802.11 [3] is used as a wireless connection of portable computers with the local network. However it still does not supply completely self configuring ad hoc networking. With the development of Bluetooth [4] a first product, designated only for ad hoc networking, is available. Due to its possibility to create and organize a network without any central management, ad hoc networking is characterized as the art of networking without a network [5].

On the other hand, a similar concept without infrastructure can be observed in the Peer-to-Peer networking area. Peer-to-peer networks are first discussed in the mid 1990s, and became famous in the late 1990s as file sharing platforms. For P2P the IP-layer provides the basic communication medium and enables IP capable terminals to reach anyone attached to the IP-network. However the IP-layer does not tell a terminal how and where to find content or other participants. These peer-to-peer networks, like e.g. Freenet [6] or Gnutella [7] are completely self organizing networks.

Similarities between both networks arise, as the basic problem, how to enable terminal to terminal communication in an unmanaged environment, is the same. However, beside the similarities there are also great differences, due to the different utilized network layers and different motivations for creating an ad hoc or P2P network.

As the routing is one of the most important modules within an unmanaged network, the routing algorithms of these two kinds of networks, will be compared in this work. As a result we want to point out similarities and differences between the Peer-to-Peer and the wireless ad hoc networking world. Thus it could be possible to make use of the synergetic effects even with completely different physical layers but the same goal, to provide networking functionalities without a given network.

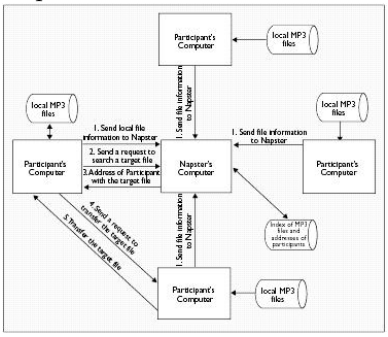
This paper is mainly about the performances of several protocol schemas about the combination of P2P network and MANET.It is structured as follows, the second section listed some related works and background study, to which we can refer to develop basic and further comprehension of P2P networks' protocol. The third section tells the evaluation of the several schemas, we're going to discuss the performances and the complexity of the routing algorithm we investigated respectively. The final section is our conclusion.

3 Background study and Related works

3.1 P2P

Since a few years Peer-to-Peer (P2P) networks came into discussion, which provide the capability to establish virtual overlay networks. So called .pure. P2P networks which are completely self organizing and therefore do not need central instances to manage the network. In this work, our understanding is according to the understanding of Peer-to-Peer networks, as described in [8]. The main characteristic of Peer-to-Peer networks is from our point of view,

- Napster



- Gnutella

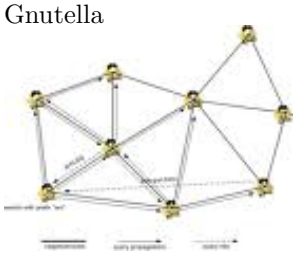


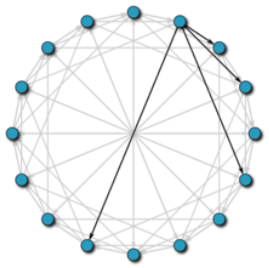
Figure 1: Napster and Gnutella

that the terminals of these networks communicate in a bidirectional and symmetric way with each other. Therefore a virtual overlay network is established above the IP-Layer (Figure 2). Such a network consists in most cases only of the nodes and the TCP/IP connections between the different nodes. The term node in this context represents the fact, that each participant in a Peer-to-Peer network acts as a server and as a client, as understood in the common sense, at the same time. Therefore the artificial word node has been created, which is constituted of the first syllable of the term server and the second syllable of the term client. Although the concept of P2P is very young, it has already became a hot topic recent years and, at the same time, the idea of p2p file-sharing has been put into application. Some of the p2p-based systems is very popular and well-known e.g. Napster(figure1), Gnutella(figure1), Chord(figure2), Pastry(figure2), Tapestry(figure2) and CAN(figure2).

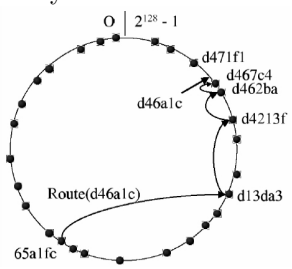
These internet P2P file-sharing platform can be divided into three periods:

- Napster had a central index server: each node, upon joining, would send a list of locally held files to the server, which would perform searches and refer the querier to the nodes that held the results. This central component left the system vulnerable to attacks and lawsuits.
- Gnutella and similar networks moved to a flooding query modelin essence, each search would

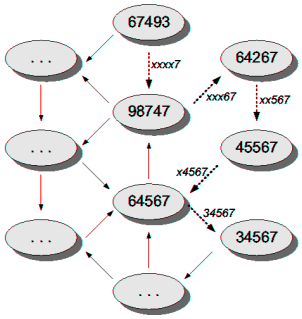
- Chord



- Pastry



- Tapestry



- CAN

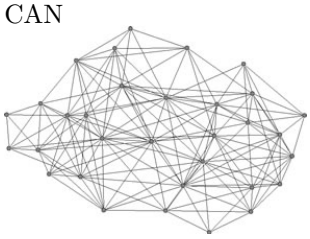


Figure 2: Some p2p systems

– Broadcast like P2P Protocol

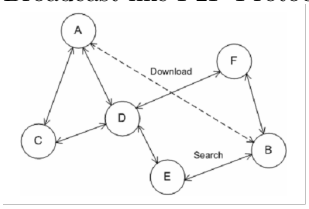


Figure 3: P2P Broadcast

- Distributed Hash Table (DHT)

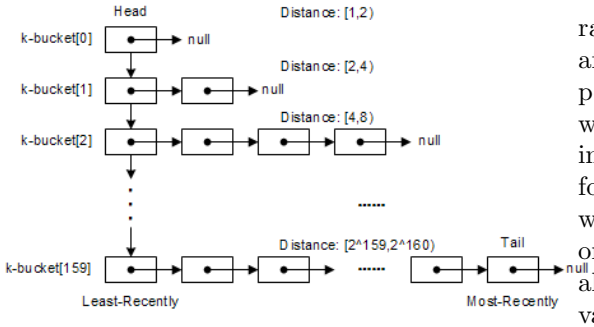


Figure 4: DHT

result in a message being broadcast to every other machine in the network. While avoiding a single point of failure, this method was significantly less efficient than Napster.The protocol algorithm can be regard as a broadcast like P2P system.

- Finally, Freenet was also fully distributed, but employed a heuristic key-based routing in which each file was associated with a key, and files with similar keys tended to cluster on a similar set of nodes. Queries were likely to be routed through the network to such a cluster without needing to visit many peers. However, Freenet did not guarantee that data would be found.

For the third kind of platform mentioned above(Freenet), a concept of DHT comes out. While talking about P2P, DHT(figure) is something we have to mention, which is also a main topic of this paper. DHT stands for Distributed Hash Table. Distributed hash tables (DHTs) are a class of decentralized distributed systems that provide a lookup service similar to a hash table; (key, value) pairs are stored in the DHT, and any participating node can efficiently retrieve the value associated with a given key.

The DHT research was originally motivated, in part, by peer-to-peer systems such as Napster, Gnutella, and Freenet, which took advantage of resources distributed across the Internet to provide a single useful application. In particular, they took advantage of increased bandwidth and hard disk capacity to provide a file sharing service.

There are many researches for DHT, too, i.e.Kademlia designed by Petar Maymounkov and David Mazires[].

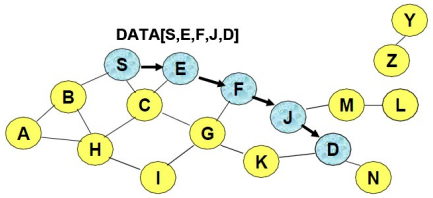
3.2 MANET

Ad hoc is first invented in the 1970s, as the "packet radio" networks (PRNETs), sponsored by DARPA after the ALOHAnet project. The topic in this paper is the MANET(mobile ad hoc network), the network is ad hoc because it exists without a certain infrastructure. Each node participates in routing by forwarding data for other nodes, the determination of which nodes forward data is made dynamically based on the network connectivity. Several different routing algorithms for ad hoc networks, with their special advantages and disadvantages have been proposed until now. They can be divided in two main branches, the proactive or table drive routing algorithms and the reactive or on demand routing algorithms. A node running a proactive routing algorithm has the full network view at every time, like a regular router in the Internet. All topology updates are broadcasted immediately or with a small time shift to all other nodes in the network. Therefore the route establishment can take place very fast. The disadvantage of proactive routing algorithms is the number of required topology updates within a time period. In case the number of nodes belonging to a network rises over a certain threshold, this kind of routing algorithm is not feasible anymore.

In contrast to that, nodes using a reactive routing algorithm do not send any kind of topology updates to its neighbors. Only in case they want to set up a route to another node, they flood a route request through the network, and get a response from the destination or an intermediate node, which knows the route to the destination by a formerly made route request.

- Destination-Sequenced Distance Vector Routing(DSDV)
  - If a router receives new information, then it uses the latest sequence number. If the sequence number is the same as the one already in the table, the route with the better metric is used. Stale entries are those entries that have not been updated for a

- Dynamic Source Routing (DSR)

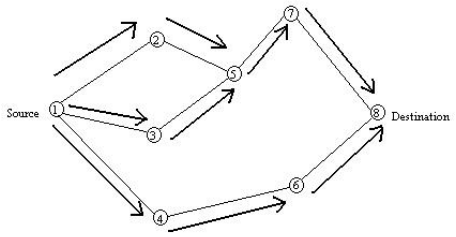


  - When S sends a data packet to D, the entire route is included in the packet header
  - Intermediate nodes use the source route embedded in the packets header to determine to whom the packet should be forwarded
  - Different packets may have different routes, even they have the same source and destination

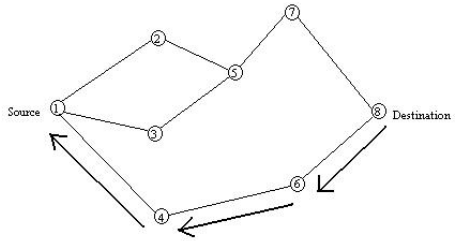
Figure 5: DSR

while. Such entries as well as the routes using those nodes as next hops are deleted. than new destination is comes this is how it works.

- Ad hoc On-Demand Distance Vector Routing(AODV)



(a) Propogation of Route Request (RREQ) Packet



(b) Path taken by the Route Reply (RREP) Packet

  - In AODV, the network is silent until a connection is needed. At that point the network node that needs a connection broadcasts a request for connection. Other AODV nodes forward this message, and record the node that they heard it from, creating an explosion of temporary routes back to the needy node. When a node receives such a message and already has a route to the desired node, it sends a message backwards through a temporary route to the requesting node. The needy node then begins using the route that has the least number of hops through other nodes. Unused entries in the routing tables are recycled after a time.

4 Performance Evaluation

Since both p2p and MANET are becoming popular only in recent years, the research on p2p systems over MANET is still in its early stage. And here in this paper, we will focus on the performance of these p2p network schemas which are very typical. The result we got is based on the users' point of view.

As we mentioned in the last section, there are many routing protocols in p2p networks and MANET respectively, but most of them come into two categories:broadcast-like and DHT-like.More specifically,most early P2P search algorithms, such as in Gnutella [9], Freenet [10] and Kazaa [11], are broadcast-like and some recent P2P searching, like in eMule [12] and BitTorrent [13], employs more or less some feathers of DHT. So what we are going to introduce are different approaches to integrate those protocols in different ways according to categories.

4.1 Broadcast over Broadcast

A broadcast over broadcast system is to employ a broadcast-like p2p routing protocol at the application layer over a broadcast-like MANET routing protocol at the network layer. in this system, searching

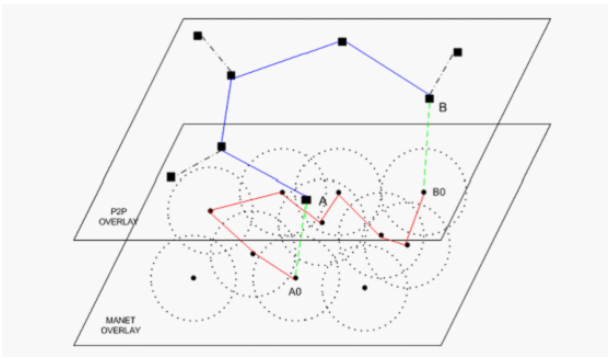


Figure 6: Broadcast over Broadcast

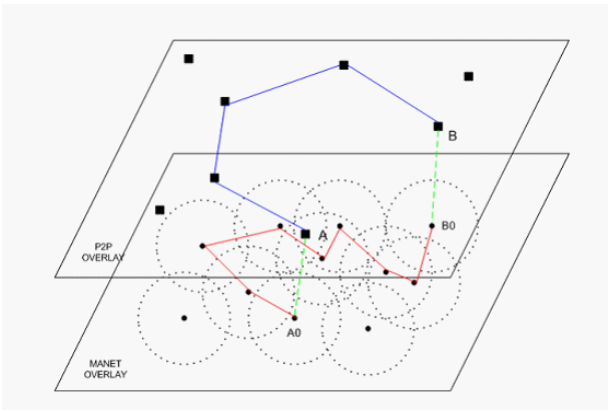


Figure 7: DHT over Broadcast

requests are broadcasted to virtual neighbors at the application layer while at the same time, the requests forms another full broadcast to all physical neighbors at the network layer.

The scheme is illustrated in (Figure) with a searching example: peer A in the P2P overlay is trying to search for a particular piece of information, which is actually available in peer B. Due to the broadcast mechanism, the search request is transmitted to As neighbors, and recursively to all the members in the network, until a match is found or timeout. The blue line represents the routing path at the application layer. Then we map this searching process into the MANET overlay, where node A0 is the corresponding mobile node to the peer A in the P2P overlay, and B0 is related to B in the same way. Since the MANET overlay also employs a broadcast-like routing protocol, the request from node A0 is flooded (broadcast) to its directly connected neighbors, which themselves flood their neighbors etc., until the request is answered or a maximum number of flooding steps occur. The route establishing lines in that network layer is highlighted in red, where we can find that there are few overlapping routes between these two layers though each of them employs a broadcast-like protocol. This approach is probably the easiest one to implement, but the drawback is also obvious: the routing path of the requesting message is not the shortest path between the source and destination (e.g. the red line in Figure 1), because virtual neighbors in the P2P overlay are not necessarily physical neighbors in the MANET overlay, and actually these nodes might be physically far away from each other. Therefore, the resulting routing algorithm complexity of this broadcast over broadcast scheme is unfortunately $O(n^2)$ though each layers routing algorithm complexity is O(n) respectively.

4.2 DHT over Broadcast

A DHT over Broadcast system is to employ a DHT-like p2p routing protocol at the application layer over a broadcast-like MANET routing protocol at the network layer.

In the early years of p2p, the scalability problem of broadcast-like protocols has long been observed and many researches and improvement schemas are proposed. As we discussed, DHT protocol does not search for file randomly like broadcast, which can give some improvement to the situation.

The scheme is illustrated in Figure 4 with the same searching example. Compared to the previous approach, the difference lies in the P2P overlay: in a DHT-like protocol, files are associated to keys (e.g. produced by hashing the file name); each node in the system handles a portion of the hash space and is responsible for storing a certain range of keys. After a lookup for a certain key, the system returns the identity (e.g. the IP address) of the node storing the object with that key. The DHT functionality allows nodes to put and get files based on their key, and each node handles a portion of the hash space and is responsible for a certain key range. Therefore, routing is location- deterministic distributed lookup (e.g. the blue line in Figure 4).

DHT over Broadcast approach is obviously better than the previous one, but it still does not solve the shortest path problem as in the Broadcast over Broadcast scheme. Though the P2P overlay algorithm complexity is optimized to O(log n), the mapped message routing in the MANET overlay is still in the broadcast fashion with complexity O(n); the resulting algorithm complexity of this approach is as high as O(n log n).

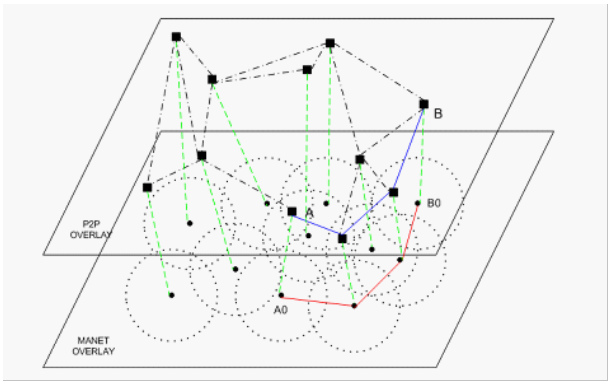


Figure 8: Cross-Layer Broadcast

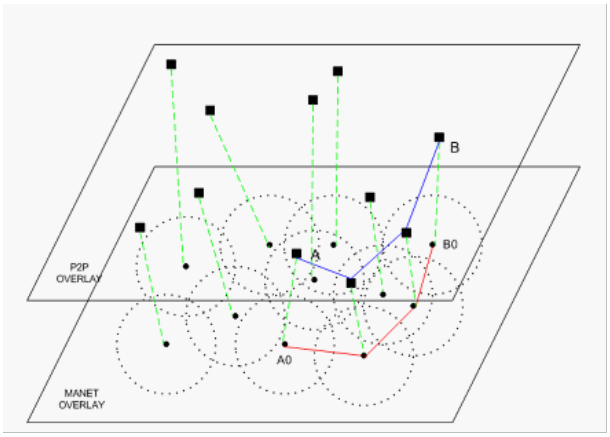


Figure 9: Cross-Layer DHT

4.3 Cross-Layer Broadcast

What we can do to improve the Broadcast-Broadcast approach is to set up a Cross-Layer Broadcast. In the former Broadcast-Broadcast network, the p2p broadcast protocol is at the application layer while the MANET broadcast protocol is at the network layer. And here comes the problem,when the p2p routed a neighbor node, it could be the among the farthest nodes at the network layer, thus results in inefficient and nondeterminacy, which always leads to a bad performance.

The Cross-Layer Broadcast routing protocol is a solution to this problem, Due to the similarity of Broadcast-like P2P and MANET protocols, the second broadcast could be skipped if the peers in the P2P overlay would be mapped directly into the MANET overlay, and the result of this approach would be the merge of application layer and network layer (i.e. the virtual neighbors in P2P overlay overlaps the physical neighbors in MANET overlay). The scheme is illustrated in Figure, where the advantage of this cross-layer approach is obvious: the routing path of the requesting message is the shortest path between source and destination (e.g. the blue and red lines in Figure 6), because the virtual neighbors in the P2P overlay are de facto physical neighbors in the MANET overlay due to the merge of two layers. Thanks to the nature of broadcast, the algorithm complexity of this approach is O(n), making it suitable for deployment in relatively large scale networks, but still not feasible for Internet scale networks.

4.4 Cross-Layer DHT

This is not hard to comprehend, with all the protocols presented above, the Cross-Layer DHT protocol, which is shown in figure. The algorithm complexity would be optimized to O(log n) with the merit of DHT, which is advocated to be efficient even in Internet scale networks. But regrettably the implementation is not possible at the moment, for there is no existing well designed DHT-like MANET protocol, in spite of some researches[] have been made of

5 Conclusion

	Efficiency	Scalability	Implementation
4.1	$O(n^2)$	N.A.	Easy
4.2	$O(n \log n)$	Bad	Medium
4.3	O(n)	Medium	Difficult
4.4	O(log n)	Good	N.A.

- The cross-layer design coordinates P2P protocols at application layer and routing protocols at network layer, which offers significant performance improvement in Broadcast and DHT approach.
- The Broadcast approach can be easily implemented for MANETs of small size.
- DHT approach is scalable to large networks. But its routing table and neighborhood table need to be carefully maintained. The proposed approaches apply to any DHT-based algorithms, such as Chord, Pastry, Tapestry and CAN.

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[12] eMule: http://www.emule-project.net/

[13] BitTorrent: http://bittorrent.com/