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EFFICIENT DATA SHARING AND ITS APPLICATION IN MOBILE ADHOC NETWORKS

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Abstract- With the tremendous growth and development in the field of wireless and mobile networks, mobile users now have increasing interests to have access to applications and data through their mobile handheld devices regardless of location, time, and computation environment. Peer to Peer (P2P) communications have been widely used for file sharing in Internet and wired networks and there is a need to have the same functionality in this domain as well. Mobile Adhoc network (MANET), which inherits all the characteristics of wireless networks follow the same idea of P2P to create a network without the help of any central entity. Thus the combination of both, creates new services and possibilities, but also faces several problems. The objective of the paper is to propose a new MANET routing protocol or modify an existing one so that file sharing applications can run efficiently on MANET with satisfactory performance.

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Introduction

Peer to peer networks

P2P [GCK01] architecture is different from a client/server [GCK01] model. In a client/server model, the client sends requests t o the server and the server responds to these requests a n d acts on them; while in P2P model, each peer can function as a client or a server depending on the requirement. The main difference between client/server model and P2P model is that in a client/server model data exchange and communication goes through a central server whereas in a P2P model, the peer systems communicate and exchange directly. P2P model allows user to share files, video, audio etc.

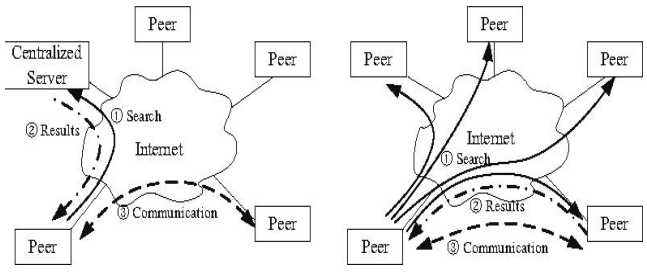

Fig. 1- Types of P2P Networks From[RM7]

Thus P2P model can be considered as the distributed sharing of resources and services by direct exchange between peers that are accessible by other peers. Popular examples of P2P networks include Napster, Gnutella, and Bit Torrent etc. As shown in Figure 1, there are mainly two types of P2P networks.

Centralized P2P Networks

Centralized P2P [GCK01] utilize a central server to provide only the index of the distributed files to the peers. Each peer uploads the file index to the central server. When a peer wants to download a file, it sends query to the index server to request for the file. Then the central server will find an available peer that contains the file and send the reply with
the destination peer address. Although the query approach relies on a central server, but after getting the content destination, the query peer downloads files directly from the destination peer by HTTP.

Distributed or Pure P2P Networks

Pure P2P [GCK01] has no central server at all. As shown in Figure 1, a peer requests the desired content by broadcasting the queries to all its neighbors. Then its neighbors continue flooding

the requests to the further nodes until the Time to Live (TTL) is exceeded. When the peer who holds the needed file gets the request, it responds to the query and a download session will be established between source and destination peer. The drawback of pure P2P is that it generates a large amount of control traffic by flooding. Since the routing mechanism is based on best effort, therefore, a query node may not get the reply even if the destination is available in the network.

Mobile Adhoc Network

MANET[SB04] is characterized as an infrastructure-less mobile wireless network, in which two mobile nodes communicate with each other through intermediate nodes. Since there is no explicit server, every mobile node should work autonomously. In an ad hoc network, the topology changes very frequently, as nodes may join and leave the network. Thus routing in ad hoc networks has to be different from routing in wired networks to handle the issue of mobility, frequently changing topology, route breaks, low bandwidth and high delay, interference, limited energy of mobile nodes etc. A variety of routing algorithms for multi-hop adhoc networks have been proposed. These protocols should have characteristics like minimal control and processing overhead, multichip routing capability, dynamic topology maintenance etc. Routing protocols are mainly classified as proactive and reactive routing protocols.

Proactive routing protocols [SB04] designed for ad hoc networks are derived from the distance vector and link state protocols developed for wired networks. The main feature of proactive approach is that each node in the network maintains a route to every other node in the network at all times. Route creation and maintenance is accomplished through some combination of periodic and event-based routing updates. Periodic updates consist of routing information exchanges between nodes at set time intervals. The updates occur at specific intervals, regardless of the mobility and traffic characteristics of the network. Proactive protocols have the advantage that routes are available the moment they are needed. Because each node consistently maintains an up-to-date route to every other node in the network, a source can simply check its routing table when it has data packets to send to some destination and begin packet transmission. However, the primary disadvantage of these protocols is that the control overhead can be significant in large networks or in networks with rapidly moving nodes. The most common proactive routing protocol is Destination Sequenced Distance Vector (DSDV)[C.P94].

In proactive routing protocols, a major overhead comes from the need for every node to maintain a route to every other node at all times. But in an adhoc network, link connectivity changes frequently and hence this overhead is costly. To overcome this problem, reactive routing protocols [SB04] were developed. Here routes are only discovered when they are actually needed. When a source node needs to send data packets to some destination, it checks its routing table to determine whether it has a route. If no route exists, it performs a route discovery procedure to find a path to the destination. Hence, route discovery becomes on-demand. If two nodes never communicate with each other, then they do not need to utilize their resources to maintain a path between each other. The route discovery typically consists of the network-wide flooding of a request message. The benefit of this approach is that control overhead is likely to be reduced compared to proactive approaches. The drawback to reactive approaches is that, when a route is needed by a source node, there is some finite delay while the route is discovered. In contrast, with a proactive approach, routes are typically available the moment they are needed. Hence, there is no delay to begin the data transmission. The most comm on reactive routing protocol is Ad hoc On-demand Distance Vector (AODV) [CPD03].

Motivation

P2P networking technologies are continuously gaining popularity as they provide a mechanism f or users to share files without the need for centralized servers. Substantial research efforts have been put for the success of P2P networks in the traditional, wired network environments. But with the rapid development in the field of wireless and mobile network systems, e.g., WLAN, WiMAX, 3G, 3.5G, and emerging 4G, and their ability to offer faster broadband access, mobile users now want to have access to applications and data anywhere, anytime through their mobile handheld devices.

Client-server model is dominant in the current mobile networks. Service providers try to control the content delivery from end to end. However, this centralized content distribution system has disadvantages like scalability crease in the number of mobile users and their requirements, there is a need to apply the P2P functionalities in the wireless domain to provide new services and applications. The existing wired P2P networks assume that the nodes are fixed and non-mobile. On the other hand, nodes are mobile in MANET which present new challenges from the network management point of view. In addition to the mobility issues, the mobile devices have much less resources than the nodes in a fixed network. Thus current P2P systems do not fit well into mobile environments where each node goes for multi-hop path routing.

If current P2P systems are deployed on the MANET, application layer and network layer both perform different routing mechanism which will result in multiple layer routing redundancy. Current adhoc network protocols do not fulfill the P2P requirements as they all are flooding based protocols. Moreover, the P2P applications must be well aware about the wireless network to minimize the amount of control traffic and to cope with frequent route breaks. Additionally the MANET should have knowledge of P2P application, in order to establish routes only to appropriate communication partners. This forms the motivation of my paper to design a new or modify an existing adhoc network protocol that enables P2P applications to run on MANET with minimum control overhead and satisfactory throughput.

Problem definition

Mobile Adhoc networks have special characteristics, such as highly variable connectivity, mobility, disconnection, location-dependency, energy and resource constraints, low bandwidth etc. So existing P2P networks cannot be directly deployed in such environments. New protocol or modifications to existing ones are required to facilitate P2P data sharing and dissemination over MANET. The objective of the paper is to design a protocol that will handle all the issues of MANET and enable file sharing applications to run efficiently on it. As people mainly download ringtones and music files from Internet on their mobile phones, so creating a music sharing network on MANET with P2P as the underlying technology will allow users to share the music files they have, so

that others in the same MANET can download. Thus we will mainly focus our attention on sharing mp3 files in MANET. Currently, many mobile service providers provide Push-to-Talk (PTT) service to their subscribers but its not available free of charge. In order to demonstrate the usage of file sharing applicati on in MANET, a prototype implementation of PTT service by establishing a small Bluetooth based Ad-Hoc network for real-time voice communication will be done.

Survey

Substantial research efforts have been put for the success of P2P networks in the wired network environments. Several structured and non-structured approaches have been used for the construction of P2P overlays over the wired network. In non-structured overlays like Gnutella, peers discover each other by flooding the network and then downloading the file from the selected peer. The P2P application is not aware of the topological location of the other peers. In case of structured overlays, an overlay routing algorithm is used to locate the content in the network. Several structured overlay networks have been proposed like CAN[SS01], Chord[ISB03], Pastry[A.R01] and Tapestry[BA01]. All of them use Distributed Hash Tables (DHT) in their routing of lookup requests. Such tables allow the lookup to scale logarithmically with the number of nodes in the overlay. On the other hand, we have Bittorrent [SR06], which is one of the Internet's most efficient file distribution protocols. It is known to perform very well over the wired Internet where end-to-end performance is almost guaranteed. However, it uses a centralized tracker to discover neighbors.

From the literature survey done on P2P protocols in wired networks, following are the main challenges in deploying and using file sharing applications over MANET. P2P systems use flooding for peer discovery and selection. Since these systems are running on wired networks, which provide very high bandwidth flooding is not a major issue. But in MANET, wireless link has very low bandwidth. So we need to restrict the number of control messages to be used for peer discovery. In wired networks, P2P nodes do not distinguish between communication partners in close proximity and those far away. But in MANET, peer selection has to depend on the proximity of a node from the source node because nodes are mobile. If the node goes out of the transmission range of the source node, data transfer will terminate. MANET will try to create a new route to the destination. However, if the same data is available at some other node at less cost after the network topology changed, the source node should download data from that node. Thus a node should be capable of classifying incoming search replies according to their hop distance to destination. In wired networks, P2P networks use multi-hop connections only for search requests. Data downloads use direct TCP connection between source and destination. Thus P2P networks work on the assumption that the underlying network is stable whereas in MANET, there are frequent route breaks. This issue has to be dealt in MANET. Network topology changes very frequently in MANET as compared to wired networks. So the P2P network should be aware of the underlying wireless network so that it minimizes the number of control packets and can cope up with frequent route breaks. Similarly the network layer of MANET should have knowledge of P2P network, so that it establishes connection with the peers in close proximity.

With the growth in the field of mobile and wireless networks, research efforts have been put for the deployment of P2P networks on MANETs. Although MANETs and P2P networks share a number of characteristics, such as self- organization, scalability, and decentralized information dissemination and discovery, many of the existing P2P architectures cannot be deployed in MANETs without modification. The rest of the literature survey describes the work done in the above area and the approaches used to overcome the challenges of deploying P2P in MANET.

Seven degrees of freedom (7DS)[Sch00] is a P2P data sharing system which enables mobile devices to discover each other and communicate even in the absence of a global connection such as Internet. 7DS exploits nodes' mobility for information dissemination and resource sharing in mobile disruption-tolerant networks. Thus 7DS presents an architecture that enables the sharing of information among mobile and wireless hosts that are connected to the Internet. Nodes in the system obtain data from Internet-connected servers, cache them and exchange them with others who are interested in them. The system exploits the fact that there is a high locality of information access within a geographic area. It aims to increase the data availability to nodes with lost connectivity to the Internet.

[DB04] has presented protocols for P2P file sharing over MANET. The simplest approach is to use a broadcast-based P2P file lookup protocol over MANET. Specifically, the file request message at application layer will be broadcasted to every virtual neighbor peer in the P2P overlay. But it suffers from the scalability problem due to the double broadcasts. The second protocol which uses DHT-based searching is more scalable. Here every file name and peer ID is hashed to a key by standard hash algorithms. Every peer should maintain a small routing table of size O (logn), in which each entry directs to an intermediate peer closer to the requested key. The peer closest to the requested key knows the address of the actual peer storing the requested file.

[SKG03] proposed the application of Tornado coding to data dissemination in mobile ad-hoc

networks, with the objective of enabling efficient and reliable peer-to-peer data sharing among mobile users. Their solution consists of a Street- and-Building mobility model suitable for modeling mobile users in a regulated civilian environment and a peer-to-peer data dissemination protocol to disseminate Tornado encoded file segments (packets). In this approach, each peer is not aware of the requesting peers around it, and the order of packet broadcast is determined randomly. Such a design significantly improves the system scalability and reduces the overhead and complexity of both supplying and requesting peers. The only non-trivial overhead introduced is the Tornado decoding performed by the requesting peers.

In [DCY02] Chakraborty has presented the GSD protocol, which is a service discovery protocol for ad-hoc networks, based on concepts of Bounded advertising of services in the vicinity, Peer-to-Peer dynamic caching of service advertisements, Service group-based selective forwarding of discovery requests. The first one means that peers continually advertising the services they provide, such as sharing a file. Bounded advertising means that there is a hop-limit on each advertisement.

Every peer that forwards an advertisement decreases the hop-counter, and when it becomes negative, the advertisement passes

away. The second concept means that the arrived advertisements get cached at peers. Aside from advertising their own services, the peers also advertise the so-called groups of services they have seen. GSD uses a hierarchical grouping of services, which is very efficient compared to other approaches.

[TZ04] presented an approach that forms clusters in DHT-based P2P overlays based on physical proximity. By grouping physically close nodes into common overlay clusters, it is possible to decrease the number of physical hops per overlay hop Thus, the amount of physical traffic generated by overlays deployed on top of mobile and wireless ad- hoc networks can be reduced significantly. Thus when an overlay node searches for a file, it will first query its own cluster. Only if that query fails, will the node start a global query.

Optimized Routing Independent Overlay Network (ORION) [AKW03] tries to provide P2P functionalities in a MANET scenario. However it concentrates only on file sharing applications. ORION is based on AODV and Simple Multicast and Broadcast routing protocol for MANET. It is a file discovery algorithm based on keyword searching. ORION combines application-layer query processing with the network layer process of route discovery. It maintains two routing tables: a response routing table generated in the network layer and a file routing table generated in the application layer. The processing mechanism for the response routing table is similar to that of AODV for MANET. The file routing table is constructed from the cache information of adjacent nodes. ORION resolves the problem of redundancy found in the file routing tables on the route with the aid of a response routing table which contains the node where the target route can be found as the next hop. ORION considers the search performance as well as the transmission performance.

Multi-level Peer Index (MPI)[LcLS04] is a distributed index structure, that enables efficient peer-to-peer information sharing over MANETs. Search in MPI consists of three phases: data lookup, location look up and data retrieval. In the data lookup phase, MPI is used to find the NodeID of a nearby source node storing the required data object. The location lookup phase 2 then obtains the location information of the source node and subsequently reach the source node with the assistance of Multi-level Location Service (MLS). Requested data object is then obtained from the source node.

Scalable service discovery[FS05] is based on the homogeneous and dynamic deployment of cooperating directories within the network. Scalability of the protocol comes from the minimization of the generated traffic, and the use of compact directory summaries that enable to efficiently locate the directory that most likely caches the description of a given service. Basically the service dis- covery protocol relies on a backbone of directories constituting a virtual network. Each directory performs service discovery in its vicinity. Global service discovery within the overall network is then performed by the backbone which is composed of directories that cooperate and are dynamically deployed.

[MYS05] has presented an algorithm for unstructured overlay networks. It assumes that the target information is within two hops and constructs the routing table using a scanning table and a lookup table. The scanning table is constructed when the adhoc network is initially configured and it contains mobile nodes which can be reached directly. However, the application still needs to know the IPs for data transmission. The efficient discovery mechanism discovers the devices first and searches routing information for locating the target item. It is provided by the discovery engine which creates the routing table which is composed of a scanning table and a lookup table. Once the target is found, the reliable transmission algorithm guarantees the successful completion of requested services. It includes a reconnection engine which takes care of cases where a sudden disappearance of service nodes occurs because of the movement of users or a shortage of battery energy.

[MAZ] has presented a scalable lookup service for P2P file sharing in MANET. This method provides lookup service which operates at the network layer. It assumes that all lookup queries are forwarded from application layer to network layer to enables our method lookup service. This method is a proactive protocol which spreads files index into the network beforehand. Files indices are stored in the network such a way that lookup cost reduces to a constant factor. Thus, it avoids query lookup flooding as it happens with current P2P protocols.

Bluetooth-based Ad-Hoc Networks for Voice

Transmission[FKW02] can be used for transmitting audio using synchronous connection oriented (SCO) links. When we use Bluetooth as a physical layer for a MANET, we will have several constraints like connected-oriented nature of bluetooth, no broadcast capability, restricted number of connections, long connection set-up time etc. To overcome these problems, a new proto col Bluetooth Scatternet Routing (BSR) has been developed. It is a reactive routing protocol similar to AODV or Dynamic Source Routing (DSR) but keeps additional information on the state of links and tries to avoid long delays due to inquiry or connection setup.

The first approach tried to make P2P networking feasible in a mobile environment is JXME[Aro02] based on JXTA. JXTA technology developed by SUN micro systems is a set of open, generalized peer-to-peer protocols that allows any connected device e.g. cell phone to PDA on the network to communicate.

The Sun Java Wireless Toolkit earlier known as JXME is a state-of-the-art toolbox for developing wireless applications that are based on J2ME's Connected Limited Device Configu- ration (CLDC) and Mobile Information Device Profile (MIDP), and designed to run on cell phones and other small mobile devices.

The toolkit includes the emulation environments, performance optimization, tuning features etc to develop wireless applications.

Thus a large number of MANET routing protocols exist that use different approaches to reduce the search time to locate the peer from which the desired file can be downloaded. But very few address the issue of taking into account the proximity of the peer for peer selection, action to be taken in case the destination peer goes out of the transmission range of source peer during the process of downloading.

Algorithm Design

Approach

Almost all routing protocols available on MANET use flooding or broadcasting to distribute or exchange file and routing information among peers which becomes a scalability problem. The proposed routing protocol tries to address the issue of flooding and peer selection based on proximity. But this is a preliminary pro-

posal, and we need to analyse different possibilities.
We assume that each mobile device will share a small portion of the disk space to become a member of MANET that provides file.
Sharing service. In order to reduce the degree of flooding, we will divide the MANET 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 etc 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. This method can be considered as a kind of proactive protocol which spreads file index into the cluster. All nodes in a cluster will maintain file indices of the other files stored in the cluster. This approach restricts the flooding to the cluster of which mobile node is a part of. This will further reduce the lookup cost to a constant factor if the file is available in

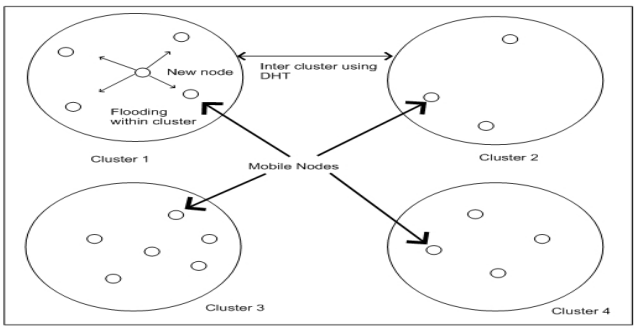

Fig. 2- Mobile Adhoc Network for file sharing the cluster.

Thus, it avoids query lookup flooding as it happens with current P2P protocols. The advantage of this approach is that since the nodes in the cluster are physically close to each other, we can decrease the number of physical hops. Thus, the amount of control traffic generated by the node on MANET can be reduced significantly.
In order to handle the case where the file is not available in the same cluster, we are exploring the possibility of using Distributed Hashing Table (DHT) used in popular P2P protocols like chord and pastry. Here every file and peer is assigned a unique key. The keys, along with the network address of the peer storing the corresponding files, are evenly distributed among all participating peers which reduces the search path length to log(N) where N is the number of nodes in P2P network. But, a single overlay hop may correspond to a large number of physical hops as the overlay network is indep endent of the underlying physical network. While this might at best be considered inefficient in wired networks, it could prove disastrous in mobile networks as the nodes are mobile. One possible solution to this problem is that whenever a node joins the MANET and forms a part of the cluster, it should periodically measure its distance from the cluster to check whether it has moved out of its old cluster and into a new one. In this case, it will assign itself a new overlay ID based on the new cluster's ID and rejoin the network under the new ID.
This will lead to physically close nodes forming clusters in the overlay network on top of MANET. When a node leaves an existing cluster, the proactive protocol that periodically ex- changes file indices within the cluster will notice the inactivity of the node and delete all the file indices corresponding to that node from the cluster.

Prototype implementation
In order to provide a proof-of-concept of the applicability of running P 2P application on MANET, a prototype implementation of a Bluetooth based MANET f or voice communication will be done.

Bluetooth
Bluetooth technology works in the unlicensed spectrum o f 2.45 GHz. When Bluetooth devices connect to each other, they form a piconet, a dynamically created network that comprises a master device and up to seven slave devices. Bluetooth also supports connections between piconets: When a master on one piconet becomes a slave on another, it provides a bridge between them. Moreover, Bluetooth is connection oriented. In Bluetooth the data transmission is controlled completely by the Master. Slaves may only transmit data after being polled by the Master. It supports two transmission modes. Asynchronous Connectionless (ACL) data transmission implements error detection and retransmission. Synchronous Connection Oriented (SCO) links need to be established explicitly and only after an ACL connection has been setup. Each SCO link reserves 64kBit/s of bandwidth which is sufficient for voice transmission.
In addition to this, it is a low-cost, short- range wireless technology. It has the capability to create a MANET dynamically, that enables mobile devices to connect automatically and share data immediately. All the above characteristics of bluetooth makes it a potential candidate for using it for voice communication among Bluetooth-enabled mobile devices, without requiring them to be within the range.

SUN Java Wireless Toolkit
JAVA has defined JSR 82 which provides Java APIs for Bluetooth Wireless Technology (JABWT). JAVA has also come up with SUN Java Wireless Toolkit which provides an inbuilt Bluetooth simulator and API's to manage the Local Bluetooth Device settings, discover other bluetooth devices in the neighborhood, search for bluetooth devices on the discovered bluetooth devices, connect to any of those bluetooth service and communicate with it, register a bluetooth service on the Local Bluetooth Device, so that other bluetooth devices can connect to it, manage and control the communication connections. A Bluetooth-enabled application can be either a server or a client or it can behave as a true pe er -to-peer system by acting a s both se r ve r and client. As all the requirements of our application can be met by Java Wireless Toolkit, implementation will be done in JAVA. The steps to develop a Bluetooth enabled application in JAVA is as follows.
Initialization
All Bluetooth-enabled applications must first initialize the Bluetooth stack.
Server
A server makes services available to clients. It registers them in the Service Discovery Database (SDDB), advertising them. It then waits for incoming connections, accepts them as they come in, and serves the clients that make them. Finally, when the service is no longer needed the application removes it from the SDDB.
Client

A client consumes remote services. It first discovers any nearby devices, then for each discovered device it searches for services that are of interest to it.

Conclusion

The report discussed the requirement and challenges of deploying P2P applications over MANET. The rapidly growing demands from the user to have access to data and application from their mobile devices anywhere anytime will make P2P in MANETs a mandatory feature in the near future. This will give rise to many new applications and services. Improving the proposed routing protocol to handle frequent route breaks, cope up with dynamically changing topology, efficient data transfer in MANET and its simulation to analyze and evaluate the experimental results will be the main part of the future work. In addition t o this, pr otot ype implementation of Bluetooth-based adhoc network for voice communication will be carried out.

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