

File sharing in Mobile Cloudlet networks

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Abstract

Recent developments in mobile technologies have opened up many opportunities through increasingly more powerful mobile phones. These phones have become more capable in establishing reliable and coherent wireless connections as well as being able to handle more computational complex tasks. In this paper, I will discuss and compare methods of setting up an Ad Hoc Network using mobile phones whilst giving an overview of the limitations concerning energy consumptions. An Ad Hoc network is a group of mobile, wireless hosts which cooperatively form a network [2]. It is concluded that with a careful choice of protocols, it is possible to establish and maintain an Ad Hoc Network between mobile phones despite energy limitations.

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1. Introduction

A cloudlet mobile network is a set of mobile phones that communicate with each other via an Ad Hoc Network whereby each device in the cloudlet may transfer data amongst each other. Although traditionally such networks aim to transfer information such as media files, the cloudlet mobile network will aim to offer services rather than just a transfer of data. My paper will focus on tackling limitations on mobile phones that make it difficult to create such a cloudlet. Pros and cons of different routing approaches used to set up the Ad Hoc Network will be discussed. It will be shown that cross-layer protocols perform better than simply overlaying peer-to-peer searching protocol on mobile ad hoc networks [1].

2. Presentation of evidence

Many routing protocols for mobile devices have been discussed in the past. These protocols can typically be split up into DHT-Based algorithms and Broadcast based algorithms [1]. Although both protocols succeed in establishing and maintaining an Ad Hoc network, mobile phones have the following constrictions that make such an Ad Hoc network unique to create:

1. Energy consumption restrictions
2. Bandwidth limitations
3. Computational power
4. Scalability issues

2.1 Energy Consumption restrictions

Since mobile devices are dependent on battery power, it is important to minimize their energy consumption [2]. Often enough, battery consumption is thought to be synonymous with bandwidth utilization. However this is not the case as it is more important to calculate the energy consumption of both sending and receiving packets via this Ad Hoc network. In order to maximize the usage of a mobile battery, we must minimize consumption of the entire network [3]. In general, the energy consumption can be modeled using the following linear equation [2]:

$$Energy = m \times size + b$$

Where m depends on the operation, $size$ depends on the size of the network and b represents any fixed costs. The implementation of a network routing protocol that is optimized for minimum energy consumption will greatly affect the total energy consumption of the network. Scalability issues also arise as networks increase in size and will be discussed in section 2.4.

2.2 Bandwidth limitations

Mobile Ad Hoc networks change rapidly and unpredictably. Since mobile phones all share the same frequency channel, this limits the bandwidth that is available to mobile networks [4]. This puts constraints on flooding or broadcasting in the network to effectively implement a routing protocol. It also limits device discovery among mobile phones.

2.3 Computational power

Previously mobile devices did not have the computational power to establish a network, let alone offer services across the network. The drawback of utilizing these computational powers greatly increases the consumption of the mobile phone's limited battery life. As discussed, the battery life greatly depends on the algorithms and protocols implemented in establishing an Ad Hoc network. Finding the data requested and route efficiently makes use of these computational powers.

2.4 Scalability issues

Due to the potential size of cloudlets that will be formed, it is necessary to consider scalability issues that may arise once the Ad Hoc networks gets large. It will be shown that scalability issues may be resolved by implementing a routing protocol that is $O(\log n)$ [1].

3 Routing protocols

Different routing protocols pose present different problems whilst solving particular issues in mobile Ad Hoc networks. I will now discuss different known routing protocols used to establish file sharing systems over wireless mobile networks.

3.1 Broadcast over broadcast

The "brute force" method of establishing an Ad Hoc network would be to broadcast file request messages to every neighbor at the application layer as well as the network layer. The complexity of this routing algorithm suffers from scalability issues as it is $O(n^2)$ due to the double broadcasts. The advantages of implementing such a protocol would be that it is easy to maintain and implement. However, it suffers from energy consumption issues as every peer will always be listening for requests from other peers. It is possible to implement such a protocol for small mobile Ad Hoc networks, but it should be limited to testing other components.

3.2 Broadcast

The first iteration of improvement in the routing protocol would be to have a broadcast on the application layer and not the network layer. This is due to wireless networks having to employ broadcast to send data even for unicast packets. This facilitates direct interaction between applications and underlying wireless networks [1]. Although this is indeed an improvement of the broadcast over broadcast protocol, it still scales badly as networks get large. However due to the nature of broadcast, the network will still be flooded by the broadcasting messages. Consequently, such a protocol would use up the limited wireless bandwidth discussed in section 2.2 as well as increase the strain placed on the mobile phone battery.

3.3 DHT over broadcast

DHT (Distributed Hash table) is a recent searching protocol that has been applied to most p2p file sharing networks. It works by hashing each file name and user ID to a key using standard hash functions. Each mobile device on the network would then maintain a small routing table of size $O(\log n)$. It works by having the peer closest to the requested key knowing the address of the actual peer where the stored file is kept [1]. The drawback of this protocol is that it still requires underlying network protocols that uses broadcast which suffers from the scalability problem. Furthermore, DHT-based protocols are more difficult to implement and maintain. The tables that are stored need to be updated regularly and can errors may occur during this process [7].

3.4 DHT over DHT

Whilst the protocol discussed in 3.3 introducing the idea of using DHT-based protocols, it is still slower than the broadcast protocol discussed in 3.2. This is due to the fact that both routing protocols require broadcasting in either the network layer or the application layer. DHT over DHT solves this issue by applying a DHT algorithm in both the network and the application layer. This will result in a protocol of $O(\log n)^2$. Consequently, this introduces implementation and maintenance costs as both tables need to be updated regularly. This is due to the mobility of mobile phones which require frequent updates of routing tables in both layers.

3.5 DHT

Introducing a cross-layer DHT routing protocol, we will be able to reduce the complexity of the DHT over DHT approach. By merging the two tables in the network layer and application layer, we are able to hash both the file name and the network ID together into the same table. Each entry in the routing table contains a pair of key and route [1]. Once these tables are initialized via broadcast, they can be updated thereafter in $O(\log n)$ time, which greatly reduces the scalability problem. Similar to how broadcast in section 3.2 removed application layer in routing, the file search is now integrated into the network-layer. This provides a more efficient routing protocol that is scalable and efficient.

Critical comparison

Due to the similar nature between Ad Hoc networks and current peer-to-peer file sharing systems such as there being no centralized server, extending protocols implemented in peer-to-peer systems and adapting them to mobile wireless networks allow us to establish a stable network. These protocols have been tested in the past and implemented according to the circumstances at hand. Due to the limitations of mobile phones, different aspects of the protocols needed to be considered.

Although we started with the brute force method of handling routing between mobile devices on an Ad Hoc network, the Broadcast method in section 3.2 introduced establishing an Ad Hoc networking without needing routing protocols in the application layer. This allowed the protocol to implement an algorithm that has lower complexity which helped with the scalability problem. It also decreased the strain that was imposed on the mobile phone's limited battery life.

As more protocols were introduced, the maintenance of DHT tables became more complex. However due to the improved computational powers of mobile phones, these can be easily calculated if correctly implemented. Although maintenance of conventional routing protocols integrate route discovery with route maintenance by continuously sending periodic routing updates, these updates need not be sent regularly [5]. In contrast, while a route is in use, the sender is informed of any routing errors that have been encountered.

Finally, a DHT approach was taken in section 3.5 where the power of DHT tables and removing the application layer in section 3.2 were put together to form a new protocol that satisfied the mobile limitations. This introduced a routing protocol that is $O(\log n)$ which allows it to be implemented on larger networks. Although the maintenance of the routing tables becomes more complex, it is a necessary trade-off for it to be implemented on mobile wireless networks.

Below is a table that summarizes the different aspects of the routing protocols that are discussed in section 3.

Table 1. Comparison of approaches

	3.1	3.2	3.3	3.4	3.5
Routing	$O(n^2)$	$O(n)$	$O(n \log n)$	$O((\log n)^2)$	$O(\log n)$
Scalability	Bad	Bad	Bad	Good	Excellent
Implementation	Low	Low	Medium	High	Medium
Maintenance	Low	Low	Medium	High	Medium
Energy efficiency	Low	Low	Low	Medium	Medium
The Shortest Path	No	Yes	No	No	No
Cross-layer	No	Yes	No	No	Yes

(Ding, Bhargava, & Lafayette, n.d.)

Conclusion

Mobile technology has progressed in its ability to handle more computationally complex functions and applications. Although the drawback of such capabilities requires clever algorithms to maximize the usage of the phone's battery life, it is nevertheless useful to explore the new capabilities of mobile phones. Mobile wireless networks that form cloudlets are just one example of such a capability and as discussed in this paper. And whilst mobile phones suffer from scalability, energy consumption issues and

bandwidth limitations, Ad Hoc networks may still be created through the right use of routing protocols. These protocols keep in mind the limitations of mobile devices as well as scalability issues that may arise as networks get large. This paper organized different protocols that have been implemented on peer-to-peer networks and implemented aspects that were advantageous to mobile phones. Specifically the DHT routing protocol was the best routing protocol as it combined the network layer table with the application layer table to reduce the complexity of routing. Although the maintenance of these tables computationally more difficult, the improvement in mobile technology allows mobile phones to handle these table calculations. Mobiles can offer services as well as file transfer on these networks which provide an avenue for mobile cloudlet networks.

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