Toward practical implementation of Mobile Ad-hoc Mesh networks

Developing and piloting the next-generation peer-to-peer mobile applications

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***Abstract*—This paper presents an overview of the current use of ad hoc networks in mobile applications. It summarizes the history and the evolution of forming a decentralized network in which each device connects with each other as independent nodes to form a mesh network. The paper also examines the researches that have been done on the topic and the challenges MANET currently faces. Moreover, due to a lack of existing mobile application that uses MANET, an prototype application that is based on MANET is developed to examine for its potential in more practical uses. The results of this paper are applicable to a wide range of decentralized networking fields that developers can use as a solid ground to tackle with and improve the networking aspects of their applications.**

***Index Terms*—Mobile ad hoc network, Routing protocols, Mesh networking, Multipeer Connectivity**

I. Introduction

Nowadays, the proliferation of mobile communication networks has enabled many mobile applications to incorporate innovative networking concepts into practical uses. Among the various networking features, the wireless ad-hoc mesh network has demonstrated its advantages through the use of the decentralized network that does not require any pre-existing infrastructures such as wireless access points (WAP) that connects a routers as a separate device. As early as 2005, the conceptual topic of ad-hoc mesh network has been put into use in the military fields [**?**]. In mobile mesh network (MANET), each mobile phone acts as a node, or access points that each node connects with its adjacent neighbors to form a self-maintaining and resilient networking system. Aside from the usual needs for traditional centralized network settings, people sometimes need to access the internet even when there is not internet presented. **Sometimes people do not have internet access due to their physical locations and have the immediate needs for help but do not know who's nearby or can not physically ask people for help under certain situations.** To account for this problem, our team has developed a prototype app that will alleviate people's needs for emergent helps and works in both online and offline setting.

In current establishment of mobile applications that uses the MANET, the most notable of such is Firechat, which is developed by Open Garden and has been popularly used for civil causes such as the Hong Kong protests in 2015. The application uses the Apple?s Multi-peer Connectivity Frameworks, which is a peer-to-peer that allows users to chat without the need of an actual wifi or cellular connections. While the technical details of the implementation of the framework on lower level network layers are not provided, the documentation has stated that it uses "...infrastructure Wifi networks, peer-to-peer Wi-Fi, and Bluetooth [MPC Documentation]?? to enable the mesh network system.

In this paper we propose an application that is similar to *Firechat* and enables the users to communicate with nearby others in both online and offline settings. The focus of this paper is to explore various potential practical uses of MANET while developing an Multi-peer Connectivity application as well as addressing potential security issues and limitations of the status quo of using MANET for mobile applications.

II. System Architecture

Comparing to other existing mobile applications in the market, our application provides a unique and powerful experience of enabling both online and offline features and utilized various tools to reach a precise location estimation. *Firechat*, which is the only application that utilizes Apple Connectivity framework and made the headlines, was designed to be a social networking application and was unable to main a sizeable client database. Therefore, in our prototype application, we enabled sign-up features so that the users will be able to use the online mode that our applications provides to maintain a relationship with the helpers.

Our prototype application is designed to be an early product that it implements the idea that seeking and getting help should not be limited by the network constraints of the users. If the user happens to be in an area without cellular network and signals, he or she could still use our application to send out emergency requests to the nearby app users so that they can receive immediate helps. And once the user has the internet, he or she could simply log into the application to maintain.

Our prototype application is designed to have the necessary features of a conventional social-networking application and add the offline feature and also user-ranking features. Once the application launches, the user is able to choose to log in as an existing online user or log-in offline by choosing an unique display name. If the user chooses to log in online, the user would be able to switch among four bars: discover page, friend page, personal page and ranking page. On the discovery page, the user is able to discover the nearby online users or

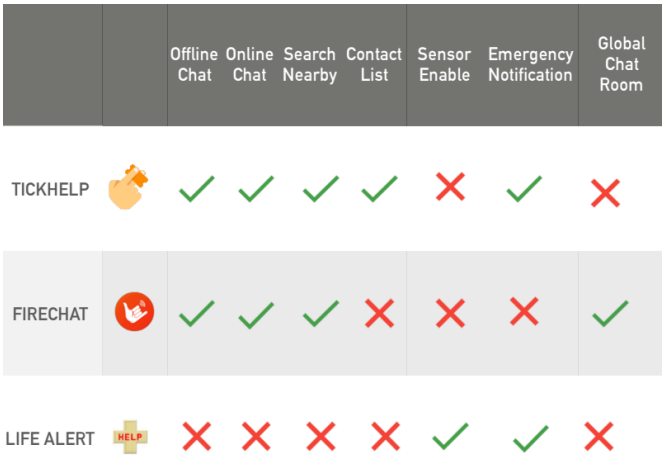

Fig. 1. Comparison of TickHelp and other similar applications on market

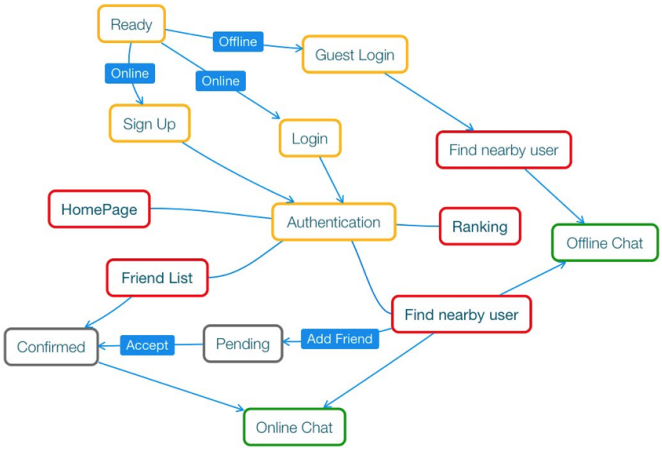

Fig. 2. Function Diagram of *TickHelp*

nearby offline users. The user could send a help request to the other users by simply clicking on the displayed names to start a one-to-one chat and could also add the other users as friends. Once being helped, the user could also give the other user a 'thumbsUp? to indicate that it has been a positive experience. Once a friend request is sent, on the second tab bar page, the user will be able to confirm the pending friend requests and list the other users as friends. On the third tab page, the user is able to upload and change his or her own profile picture to display. Lastly, the ranking page will list all the users in respect to the scores that they have received. As indicated in Figure 3, ReadyViewController will be the initial controller of our application. If the user chooses to login as guest, displayNameController will be invoked and it will allow the user to enter the name he/she wish to display. After the user clicks on the submit button, *offlineViewController* will be invoked and it list nearby users on the view through Multi-peer Connectivity Framework. When two users choose to chat with each other, a peer-to-peer session will be constructed between them, and our application will move to

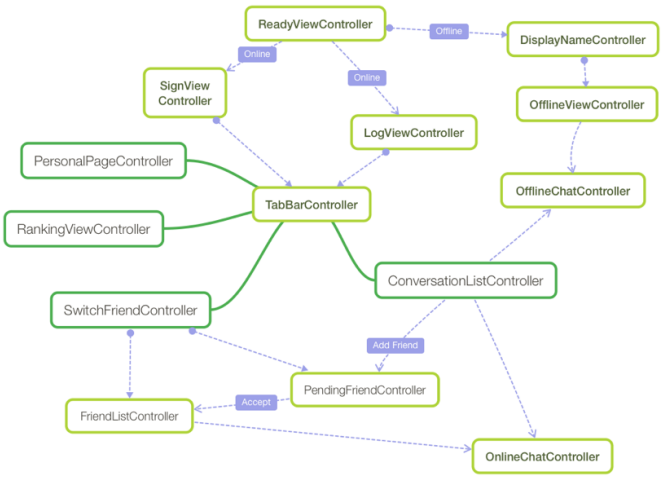

Fig. 3. System Architecture of *TickHelp*

offlineChatController, which will allow them to chat offline. Go back to the *ReadyViewController*. If the user chooses to login, our application will move to LogViewController; if the user chooses to sign up, our application will move to *LogViewController*. When the submit button on either page is clicked, *tabBarConrtoller* will be invoked. Then the controller to be invoked can be *PersonalPageController*, *RankingViewController*, *SwitchFriendController* or *ConversationListController*. When *ConversationListConrtoller* is invoked, the nearby users will be displayed. The user can either choose to chat with another user online with *onlineChatController* or offline with *onlineChatController*. When clicking on the adding button, user A can add user B as friend through *pendingFriendConrtoller*. When user B accepts the request, both user A and user B can see each other on the contact list with *FriendListController*.

III. Implementation

Our application utilizes several software resources. For our online mode, we use GeoFire for localization. With Geofire, our application is able to retrieve the location of users based on their longitude and latitude so that it can help a user to search for nearby users easily. We use Multi-peer Connectivity Framework to implement chatting and user discovery features in offline. With Multi-peer Connectivity Framework, our application can construct peer-to-peer connection between two users under the same ad-hoc network, so that user can discover and chat with nearby users with bluetooth or Wi-Fi. Moreover, we utilize several external GitHub libraries to improve the user interface of our application. For example, we use VideoSplashKit to display a short video on our onboarding page, which turns out to makes our application more visually appealing to the users.

IV. Related Works

A. History and Evolution of MANET

Ever since the mobile ad-hoc networking concept come into place, researchers and application developers have shown

interests in the wide range of usability of MANET technologies. First, an mobile ad-hoc network has demonstrated itself to be self-organizing and adaptive, as well as easy to connect or disconnect from the mesh network at a low cost [**?**]. Overtime, the life cycles of MANET could be characterized by three generations of development. As early as 1970s, MANET has been used through PRNET (Packet Radio Networks) for military purposes. It was examined for combat abilities through trials. The second generation of the ad-hoc networks dated back to the 1980s, in which time it was used as a packet-switched network without infrastructure to improve radios? performance. The last generation arrives in the 1990s, which the ad-hoc network has been examined for its commercial purposes and the idea of treating devices as a collections of nodes has been introduced in various research conferences [**?**].

B. MANET Securities and Challenges

While ad-hoc mobile mesh network has the advantages of no requirement of certain infrastructure sets, self-administration capabilities, and the elimination of costs to set up a network, it still faces some challenges that involves both technical difficulties for its operation and also security concerns [8]. To start, the mobility the individual nodes possess could lead the routing issues [**?**]. Since the pairs of nodes are allowed to move arbitrarily in the network topologies, and each individual node acts as both the host and the router in the network, it would be difficult to maintain congruent information of all nodes when one of the nodes is removed from the network [**?**]. Multicast routing, which is the routing protocol to distribute data to multiple recipients, would become more challenging because of the dynamic movements of the individual nodes. In the prototype application that our team developed, the Apple Multi-peer Connectivity SDK also experiences the issue of not being able to deliver the data occasionally. Though the phenomenon is not explicitly addressed in AppleĂ?s developer guide, it?ĂŹs likely the result of packet loss, which is when packets of data failed to reach the destination node during their transmissions, causes bit rate error and interference when nodes are being dynamically reallocated [**?**]. Moreover, the mobility of the nodes in the network would also give malicious nodes easily access to hinder the data network. Also, Inter-networking between MANET and an IP based fixed network is also a challenge and requires a more fixed coexisting routing protocols than current mobility management [**?**]. Since MANET does not have any fixed infrastructure for the nodes to base on to forward messages, the intersection of the fixed network and MANET could be challenging to implement. In our prototype application, the offline mode and the online mode are not compatible with each other because of the conflicts in the routing protocols is expected. To achieve the goal of inter-networking among IP based fixed network and MANET, more advanced routing algorithms that works beyond the current Reactive, Proactive and Hybrid routing protocols are needed. Also, the inter-networking issue of MANET could make it prone to attackers in ways that they could easily reroute or track the movements of each node [**?**]. The prior securities concerns raised of MANET could have more serious implications in the matter. Every node in MANET is not safely resided in physically protected spaces and are therefore prone to attacks. The same type of common forms of attacks that have been imposed on fixed networks could also threaten mobile Ad-hoc networks. Attacks on MANET could be characterized as active or passive [**?**]. The passive attacks only attempts to retrieve information rather than modifying network protocols. It would be extremely hard to detect because it does not modify the network or interrupt the data transmission in any way. However, during active attacks, attackers would reroute and inject information into the MANET network. The malicious node would modify the data stream and generate false routing messages [**?**]. The attack could take on various forms. The common ones are when the malicious node separates the nodes into two sets and become the intermediate node itself, forcefully reroutes the communication from one node to another wrong node, or obscures the vision of the normal nodes by hiding and misrepresent itself with the network.

C. Existing applications of MANET

Even though MANET has a long history of being used on military and ratio softwares, its usage on individual mobile devices for commercial purposes is not common. As priorly stated, the most notable mobile application that uses MANET to enable user communications system is FireChat. During the Hong Kong protests in 2015 and multiple other civil protests occasions, people have used the application to form a peer-to-peer mesh network restricting a central area when the government shuts down the internet. The FireChat application has three communications that take on different forms. It allows people to start a group chat capped at a limit of 1000 people, to join open chat rooms, and initiate conversations with nearby users. However, this app has its drawbacks. It?s security features are at a bare minimum as there is no authentication system to check if the same device name belongs to a single user. Also, the chat system is not meant for a private and secure communications and the messages that have been exchanged are prone to be obtained by third parties [**?**]. However, as MANET develops rapidly in the field of mobile computing due to its exceptional feature of requiring low costs to maintain and flexibility, researchers has listed many of its potential applications such as entertainment, sensor network, context aware services and to be embedded on Internet of Things (IoT) [**?**].

V. Summary and Future Work

The rapid developments in the field of mobile computing has enabled Ad-hoc mobile networking to take on more innovative uses than its current status quo. Its advantages of lacking a fixed infrastructure to form a self-organizing and self-maintaining wireless mesh network enables many potential uses in mobile applications with a low cost. As there are still challenges to the routing protocols and security concerns to MANET, further research for more particular algorithms or

particular class of algorithm are needed for MANET to be implemented efficiently on mobile platform applications.

By developing this prototype application, we were able to handle the situation when people need to seek help but not have immediate access to internet connections. We used both online and offline techniques to refine our search features to query the nearby users. For the future strategic development of the application, we plan to further integrate the offline and online features so that the users do not have to access the two network modes separately. By achieving this goal, the user would be able to shorten the time that is needed to send out help requests, which becomes vital given an emergency. We would integrate the settings so that application users could choose whether they would like to receive notifications from the application. If someone sends out the help requests, the requests would quickly appear on the nearby users? screens so that it could be accustomed to quickly. Also, we would add a payment feature that works compatible with Apple pay, Paypal and Venmo and the user could easily update their card informations from the settings page. By doing so, the user could make a quick tip to the helpers as a sign of gratitude and the payment amount would be preset to prevent any excessive amount. Furthermore, we would refine the security features of the application so that the payment information and the user information will be encrypted in a more secure setting. By integrating the aforementioned functionalities, we believe that we would be able to turn our app into a sellable product and truly make an evolutionary change in the application world.

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APPENDIX
GITHUB LINK

https://github.com/arieeel1110/TickHelp.