Smart Phone for Mobile Communication Community

Kefei Cheng and Qiqi Li

Abstract—**In this paper, we proposed a communication scheme of Ad hoc network based on smart phone. In the scheme, smart phones are connected to each other and set up a network to build an independent communication community, and each smart phone has routing function in the community. The community can provide mobile communication services without any costs and operators. We called this scheme as the mobile community. Based on the characteristic of this scheme, we designed the system functions as well as the communication technology of voice and text, and at the same time for the system environment, we studied the AODV protocol in Ad Hoc network and improved it as TNAODV protocol to adapt to the complexity of the system. In order to further reduce energy consumption and shorten the time required to establish communication, a cross-layer AODV routing algorithm is proposed. At last we combined the theoretical analysis of this algorithm used OPNET14.5 to stimulate performance for the system and proved the practical value of the mobile community.**

Index Terms—**Ad hoc networks, routing algorithms, smart phone, TNAODV.**

I. Introduction

In recent years, smart phone sales have increased from 174 million in 2009 to 400 million in 2012 years. In 2012, smart phone sales even have more than PC sales [1]. This shows that the smart phone has become one of the indispensable products for people's life. The important function of the smart phone is Wifi which mainly used to connect to the Internet via the AP. However, Wifi powerful function has not been effectively applied while Wifi just be the tool for surfing Internet. Ad Hoc Networks gave us a way to get away from the traditional AP.

Ad hoc network [2], [3] is an increasing important topic in wireless communications and has been regarded as one of the key features of beyond 3G systems. Ad Hoc network is made up of a set of self-organizing wireless nodes or terminals, which do not rely on fixed infrastructure, distributed management. And it is a self-creating, self-organizing, self-management and adaptive networks.

Smart phones, with independent operating system, can be installed the program by the customer. We establish a system of Ad hoc network based on smart phone platform by WiFi in this paper. Based on its characteristic and network system, we propose a mobile community communication system, which utilizes wireless capability in smart phone to establish an Ad hoc network system for achieving communication among terminals. Mobile community is a communication model which one smart phones exchange information with other smart phones via WiFi in certain area; it is free and convenient, is applied various environments such as entertainment, travel, emergency communication and so on.

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Kefei Cheng and Qiqi Li are with the College of Computer Science and Technology, Chongqing University of Posts and Telecommunications, China (e-mail: 670891028@qq.com).

II. The Research for Technical Scheme

In the mobile community system architecture, each smart phone node are equal, there is no central node. One node can transmit information to the other node via WI-FI. The formation of the Ad hoc network for real-time communication does not require additional infrastructure. Smart phone terminals in the system are working independently, when they need to communicate, they initiated TNAODV protocol, as shown in Fig. 1: when Smart phone node 1 wants to communicate with smart phone node 4, smart phone node 1 initiated RREQ, then phone node 2 forwarded to smart phone node 4, smart phone node 4 received RREQ after forwarding N times, at last smart phone node 4 replied RREP to the smart phone node 1 to complete this process, now there establish a connection between the smart phone node 1 and the smart phone node 4.

A. Network Function

Each node of mobile community is independent and equal, and should include the function of customer, service, and routing. According to a communication process of the system, mobile community is divided into the following five functional modules.

1) Query module

Smart phone use Wifi to search and construct Ad hoc network, at the same time smart phone to mark their own by broadcast, the interface provides the user search function to query other users, and to scan the user information (including Mac address, user name and routing information).

2) Voice processing module

On the side of information transmitting, we can use the built-in microphone of the smart mobile terminal to collect the voice signal, and then digitized voice signal, using a suitable coding for data compression. On the side of information receiving, extracting the received voice signal, this voice signal may play in the built-in headset of smart phone terminal.

3) Short message processing module

On the side of information transmitting we can acquisition of the text information signal with the smart phone terminal information transmitting center. Then transmit the text information after added the UDP message at the beginning of the text information. On the side of information receiving, display the signal of the information in the smart phone terminal receiving center.

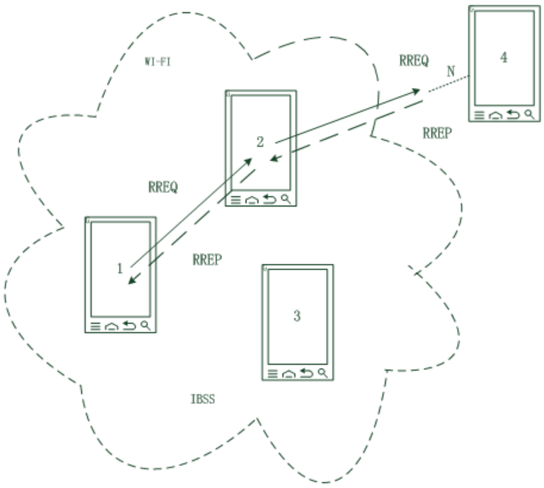

Fig. 1. The system architecture of mobile community.

4) Routing module

The source node can initiates a routing query and create routing and maintain routing information. The intermediate node and destination node response to the source node with establishing the bi-directional data communication lines between the origin node and the intermediate node or the destination node, and the intermediate node and destination node can be adjusted and maintained according to the changes of network situation.

5) Wireless transmission module

We can get all information within Ad Hoc network by Wifi management on the smart phone terminal. And periodic maintenance and update the networks, send data packets according to the path selected by the routing module.

B. Routing Protocols

1) Requirement analysis of routing protocol

Ad Hoc network routing protocols has been hot topic for researchers, and there are a lot of classic routing protocols according to the characteristics of the network. These protocols are generally divided into the table-driven routing protocols and on-demand routing protocols. In Table-driven routing protocols, each node has a whole routing table, the routing table requires frequent updates to adapt to the changes in the structure of the network dynamic topology. While, in on-demand routing protocol, when a node needs to send data it will establish an appropriate routing, the routing table is only for the current need of routing information. Because the terminal of our system is the smart phones, it has high mobility and rapid topology changes, table-driven routing protocols will have to waste bandwidth as well as increase the terminal's power overhead, so we choose the on-demand routing protocols in our system.

The most popular protocols in on-demand routing protocols are DSR and AODV. In our system, AODV protocol [4]-[7] is more suitable to the changes in the network topology and energy-constrained conditions because it absorbs the benefits of the DSR protocol and DSDV protocol. However, we find that there exit the following problems in the AODV routing algorithms with applied in mobile community:

1) Send RREP packets only which destination or neighbor nodes receive RREQ packets.
2) Nodes can't sense the status of links without extra control packets.
3) After a link is break, restart routing request messages, rather than repair the break link.

Based on the weakness of AODV and routing overhead in mobile community, the classic AODV routing algorithm is unsuited for our proposed environments that nodes can be mobility and the link is easily disconnected. To address these problems, we propose a new TNAODV protocol based on the improvements of AODV protocol.

2) Protocol principles of TNAODV

Based on the above problems, we propose an improved efficient AODV routing algorithm-TNAODV, which adopts the mechanism of two-hop neighborhood information to reduce the time of routing building, speeds sensing the status of links through cross-layer among network layer, MAC layer and physical layer, then reduces control overhead for link break. The algorithm step shown in Fig. 2.

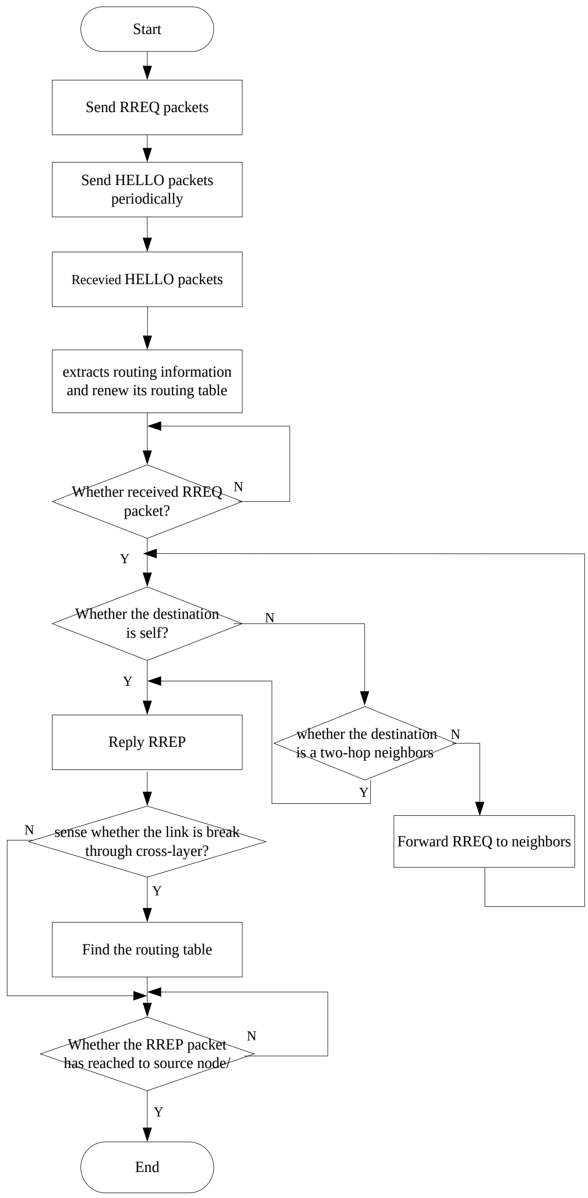

Fig. 2. The algorithm description of TNAODV.

TNAODV protocol includes the following six steps:

Step 1: In TNAODV algorithm, the nodes broadcast periodically the local (1-hop) HELLO packets which includes a node's neighborhood information from their network layers. If a node receives a hello packet and extracts routing information, it will renew its routing table.

Step 2: Nodes can sense the information from other nodes through carrier sensing of the PHY layer, if a node sends a frame which includes data frames and control frames expert broadcast frames, it will receive an ACK frame from neighbor.

Step 3: if a node sends a copy of RREQ or RREP packet from network layer, it will send cross-layer information with "1" or "0" to MAC layer (if sending a RREQ packet, cross-layer information is "1").

Step 4: if the MAC layer of a node receives cross-layer information, it obtains the value of information. If it receives an ACK from opposite, it will notify the network layer by cross-layer information sharing.

Step 5: After the network layer receives the cross-layer information, it will delete the copy of RREQ or RREP packet; or resends RREQ or RREP packets with referencing routing table.

Step 6: if the network layer of a node receives a RREQ packet from neighbor, it will seek the routing with reaching destination. If it searches the information, it will generates a packet in the network layer, send to neighbor with sending RREQ packet.

III. The Key Technique Analysis

The establishment of mobile communities needs to address several key technical issues, including service discovery and access, voice and text communication, TNAODV protocol cross-layer design.

A. *Service Discovery and Access*

Recently, the Wifi function has Ad Hoc network mode on smart phone, when the terminal access to this mode, the wireless card will be sent broadcast UDP messages periodically which including the MAC address, IP address, user name, and routing information to mark the presence of the wireless card. Meanwhile, the wireless card will be enable the accept function, ready to accept and analyze the broadcast information transmitted by the other terminals in the network. Based on this basic principle, we provide a user search function in the user interface, which present broadcasting information collected by wireless card according to a certain manner.

The working environment of the system is the IEEE802.11 protocol wireless LAN, while the majority of the IEEE802.11 wireless LAN uses industrial frequency ISM2.4GHz. There are many interference in this frequency band, coupled with the transmission bandwidth is limited, so the broadcast cycle can not be too small, otherwise they will cause much terminal overhead, at the same time, in order to discover new nodes, the system's broadcast cycle can not be too large. On the basis of various circumstances, we define the number of the node within fifty. Through a series of tests, we make the broadcast cycle in 8 seconds, and in this broadcast cycle, it is possible to effectively detect the new node and will not bring an excessive burden to the network.

B. *Voice and Text Communication*

The terminal of the system is a smart phone. The electricity of smart phone has certain limitations, combined with call speed requirements of the system are relatively high, we use the UDP protocol Socket Communications taking into account the complexity of the Ad Hoc network. Used UDP protocols to communicate do not need connection. Although there is a certain degree of defects in reliability, it does not have so much impact [8].

HTTP / TCP is responsible for the transmission of the control information, and it uses RTP / UDP to transmit real-time voice information, uses UDP to transmit real-time voice stream which similar with RTP mechanism. Text communication can be simply realized by add text in UDP messages, which is, we can generate a UDP packet used IP address and text content, and then transmitted it.

Server-side:

1) Establish the socket of server, starts listening for connection requests across the network.
2) Sent the connection request information secretly to the client when detects the connection request from the client, then establish a connection between the server and client.
3) Upon completion of the communication, the server closes the connection with client.

Client-side:

1) Establish the socket of client, ensures the host name and port of the server you want to connect.
2) Send a connection request to the server, and waits for the server's feedback information.
3) Conduct data interaction with the server after a successful connection.
4) After data processing, closes socket connection.

C. *TNAODV Cross-Layer Design*

We propose an improved algorithm (TNAODV) which adopts cross-layer design to utilize algorithm performance, its detail as following.

1) Nodes can deter information from other node sending through carrier sensing; at the same time, a node send each frame (except network layer send broadcast packets), the MAC layer of neighbor response an ACK frame.
2) If the network layer of a node sends a copy packet of RREQ or RREP, the network layer sends cross-layer information ("0"or "1") to MAC layer(if a node sends a RREQ packet, it will send cross-layer information with "1").
3) If the MAC layer of the node receives the cross-layer information, it will report the network layer by sharing cross-layer information when it sends a frame within the RREQ packet and receive an ACK frame from neighbor.
4) If the network layer of the node receives the cross-layer information from MAC layer, it will delete the copy of RREQ or RREP packet; if not, it will refresh its routing table and resend RREQ or RREP packets according to routing table.

IV. Performance Analysis

Cross-layer mechanism makes TNAODV outperform the classical AODV routing algorithm in terms of end-to-end delay, control overhead, success ratio and so on [9].

A. Algorithm Convergence

Because both of them utilize DV (Distance Vector) algorithm, TNAODV and AODV have the same convergence performance. If there is a path to destination and packets will be sent and received correctly, TNAODV can find the path in a limited time. Furthermore, there are not loops and counting to infinity in routing process.

B. Computing Complexity

Utilizing some new fields, TNAODV increases the memory storage nodes. But there is not signification. The storage complexity is equivalent to the one of AODV, and it is $O(N)$, N is the total of nodes.

C. ETE (End-to-End) Average Delay

$$\overline{T} = \sum_{i=0}^{N} (rt_i - st_i) \Big/ N \tag{1}$$

Where rt_i is the time of the i packet reached destination, st_i is the time of the i packet generated. Because TNAODV algorithm utilizes two-hop neighbor information for reducing the time of routing. Under the same load, it will reduce the time of packets reached destination

D. Control Overhead

$$C = P_C / (P_C + P_D) \tag{2}$$

P_C represents the bit number in all the control packets. P_D represents the bit number in the data packets that reach their destination. TNAODV algorithm adopts cross-layer design to reduce the number of RREQ and RREP packets, so it decreases control overhead.

E. Success Ratio

$$S = D_D / D_S \tag{3}$$

where D_D, D_S show the number of received and sent packets, respectively. TNAODV algorithm reduces the time of packets reached destination, so it make more data packets reach destination under the same load.

V. Simulation Results

A. Simulation Environments and Parameters

We execute lots of simulation to compare the performances of TNAODV with the classical AODV algorithm in terms of end-to-end delay, success ratio, control overhead.

The simulation environments [10] consists of 40 mobile nodes evenly and randomly moves on a rectangle area of 400m*400m.Nodes move using the Random waypoint model with a speed 0m/s, 5m/s, 10m/s, 15m/s and 20m/s, the transmission range of nodes is 300m. The traffic model is 1packets/s, and the destinations are random. The packet length is 1024bit.the MAC protocol is 802.11b, and the channel rate is 1Mbps. The simulation period is 600s.

B. Simulation Results Analyse

1) Average end-to-end delay

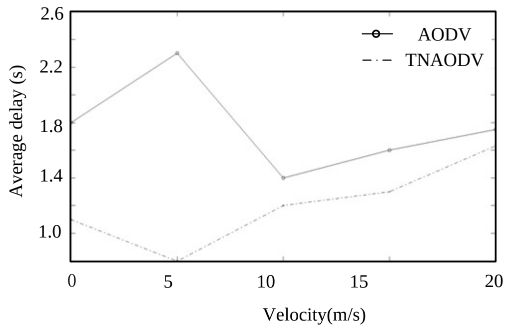

Fig. 3. The comparison of average end-to-end delay.

As illustrated in Fig. 3, whether in TNAODV or AODV, the ETE average delay increases as the increasing of velocity of nodes. The velocity of nodes increases, the probability of link breaking off increases, too. Then, the number of retransmitting packets will increase. So, the ETE average delay increases. But in TNAODV, less control packets and more success ratio of routing building will make transporting more fluent. So the communication technology of mobile community has a very prominent anti-latency network performance.

2) Success ratio

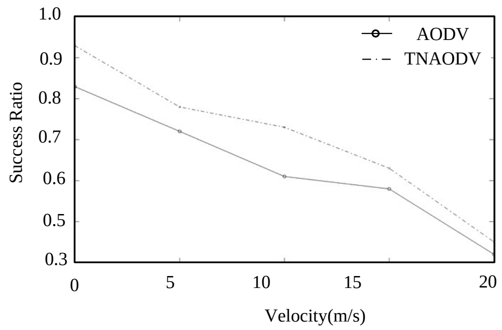

Fig. 4. The success ratio of TNAODV and AODV.

As shown in Fig. 4, TNAODV is better than AODV in success ratio. The reason is that TNAODV can make data packets reached destination fluently.

3) Control overhead

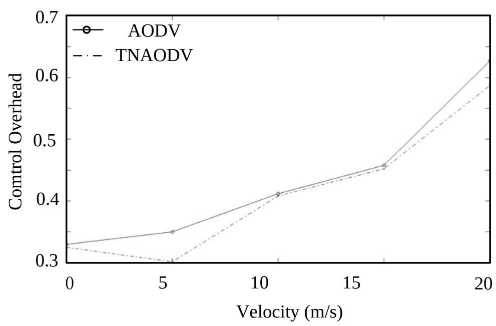

Fig. 5. The comparison of control overhead.

As shown in Fig. 5, there is an apparent difference in protocol overhead between TNAODV and AODV. The core idea of TNAODV is just to decrease the control overhead.

Because it reduces the number of RREQ and RRER packets.

As can be seen from the results, our proposed TNAODV protocol overall performance is better than AODV protocol, and our proposed TNAODV protocol further verify the reliability of the mobile community communication technology, especially the speed between 0m/s and 5m/s which similar to the people walk interval. The mobile community showed superior performance in communication delay, the success rate, and cost control.

VI. Conclusion

In this paper, our technology proposal of mobile community can achieve the formation of a completely free mobile communication community with smart phone. The community members within mobile community can view information of each other, to know each other's, and can be carried out voice and text communication with freedom for free. Such mobile community either can be used as a way for emergency communications, or can be used on a trip, outing on the road, and a wide range of suitable entertainment work environment. According to the technical scheme of our proposal, a cross-layer AODV routing algorithm is proposed, it adopts two-hop neighborhood information and the link status of cross-layer sensing to reduce the time of routing building and control overhead.

Since the energy sources of the smartest phone is still a difficult problem, we will fully consider the energy consumption factors in future studies to enhance the performance and functionality of the mobile community which fully prepared for the next 3G video calls and other functions.

References

[1] Smart phone sales, *Network and Information*, vol. 26, no. 3, pp. 5, 2012.

[2] J. Li and J. P. Zhou, “Ant colony optimization based energy aware routing algorithm for Ad Hoc networks,” *Computer Engineering and Design*, vol. 33, no. 4, pp. 1315-1318, 2012.

[3] X. J. Zhu and J. Shen, “Minimum energy consumption multicast routing in ad hoc networks based on particle swarm optimization,” *Journal on Communications*, vol. 33, no. 3, pp. 52-58, 2012.

[4] H. Liu Hu and L. L. Li, “Research and Improvement on AODV Routing Arithmetic in Mobile Ad Hoc Networks,” *Journal of Wuhan Polytechnic*, vol. 31, no. 11, pp. 10-13, 2011.

[5] From Pastry to Cross ROAD: Cross-layer ring overlay for ad hoc networks[C], Pevasive Computing and Communications Workshops, *Third IEEE international Conference* on, 2005: 60-64.

[6] D. Espes, “Adaptive expanding search methods to improve AODV Protocol[C],” *Mobile and Wireless Communications Summit*, 2007: pp. 1-5.

[7] H. P. Wang and L. Cui, “An enhanced AODV for mobile ad hoc network [C],” *Machine Learning and Cybernetics, 2008 International conference on*, 2008, pp. 1135-1140.

[8] Y. Lu, S. Q. Zhu, and X. K. Lin, “Enhanced MAC protocol for voice communication in IEEE 802.1 1 WLAN,” *Second International Conference on Digital Telecommunications*, pp. 7, 2007.

[9] S Corson and J Macker, “Mobile Ad hoc networking (MANET): Routing protocol performance issue and evaluation consideration,” *RFC2501*, 1999.

[10] Y. Q. Fan, L. Z. Wang, and H. Y. Sun, “Computer simulation of AODV routing protocol in Ad Hoc network based on OPNET,” *Journal of Jilin University (Information Science Edition)*, vol. 5, pp. 534-538, 2009.

Qiqi Li received his bachelor's degree from Chongqing University of Posts and Telecommunications, China, in 2006. He is now a graduate student for a Master's degree of Chongqing University of Posts and Telecommunications. His current research interests are in the areas of ad hoc network, communication technology and computer networks.