Application of D2D Communication System Based on Android and JXTA on the Internet of Vehicles

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Abstract. This paper introduces the development prospect of the Internet of vehicles. By combining D2D technology with cellular networks, the problem of the increasingly scarce spectrum resources of traditional cellular networks is solved. D2D Communication System based on Android and JXTA is realized by designing network topology and network settings, peer discovery and instant messaging modules and applied on the Internet of Vehicles to achieve an intelligent transportation system with high security and reliability.

1. Introduction
In recent years, China’s urbanization process has accelerated, the number of cars has continued to grow, and the amount of car possession is too high. However, infrastructure construction has not kept pace with the growth of the number of cars. Under such circumstances, road congestion, frequent traffic accidents, environmental pollution, economic losses, and waste of resources have followed [1]. To solve the above problems, the intelligent transportation system came into being. As one of the main applications of the intelligent transportation system, the Internet of Vehicles realizes the interconnection between vehicles and vehicles, vehicles and roads through advanced technologies such as in-vehicle electronic sensing devices, mobile communication technologies, car navigation systems, intelligent terminal devices and information network platforms. Thereby real-time and efficient intelligent monitoring, scheduling and management of road information are achieved [2].

In this paper, under the network architecture of LTE-V, the D2D communication technology is used to transmit data to the vehicles in the cluster for the problem of poor system reliability due to the low success rate of receiving data at the edge of the base station [3]. Under the control of cellular mobile communication technology, D2D communication as a reliable short-range communication technology allows direct communication of multiplexed wireless resources under the control of the system. The data traffic does not pass through the base station and the core network, thereby reducing the communication delay and improving spectrum utilization and system throughput [4][5]. It can effectively alleviate the load of the core network and realize data distribution, which is suitable for short-distance traffic communication on the Internet of Vehicles [6]. Under the same network, a D2D connection pair is established through neighboring vehicles, and real-time traffic safety alarm messages are transmitted, which can effectively alert traffic accidents.

The first part of this paper is based on Android and JXTA D2D system design and implementation, detailing the design and implementation process of the D2D communication system. JXTA is a standardized set of P2P protocols from Sun, providing the basic components for developing P2P-based applications. JXTA is characterized by operating system-independent, language-independent, and can
run on any device, thus satisfying development on different platforms [9]. The second part is the application of the D2D system on the Internet of Vehicles. It introduces the advantages of the vehicle-mounted network and the combination of the vehicle self-organizing network and the D2D system. The final part summarizes the main work and research focus of the paper.

2. Design and Implementation of D2D System Based on Android and JXTA

2.1 Network Topology
The target D2D system is automatically organized and maintained. It does not depend on the server. To speed up the system response and improve node management, a layered P2P network model is adopted, where nodes with different node capabilities (computing power, memory size, connection bandwidth, network retention time, etc.) are divided into two categories: supernodes and ordinary nodes. In terms of resource sharing, all nodes have the same status. The difference is that the supernodes store information about other nodes in the system, and the discovery algorithm only forwards between supernodes. The supernodes then forward the query request to the appropriate normal node. In this way, a high-speed forwarding layer is formed between the supernodes, and the supernodes and the ordinary nodes responsible for it constitute several levels [7].

Considering the combination with the JXTA protocol, the design of the D2D network structure is shown in Figure 1. The newly launched node first requests to join the network from the rendezvous point RDV (the supernode in the hierarchical structure). The rendezvous points feedback a list of nodes in the network and forward the online messages of the nodes. The node obtains a list of nodes and stores them in the cache so that it can communicate with other nodes according to the list.

![Figure 1. D2D Network structure.](image)

2.2 D2D system overall design

![Figure 2. Schematic diagram of D2D system based on JXTA.](image)
The D2D communication system mainly realizes instant communication between nodes and nodes, and the system hierarchy is divided into three modules: network configuration, discovery node, and message transmission. The network configuration module is to build a Wi-Fi-based entity bearer network for the D2D system. The discovery module is mainly used to search for network peers and maintain a list of network nodes, which is the basis for completing message transmission. The message transmission module is implemented by establishing a connection to a target user and sending a message. As shown in Figure 2, the D2D system is first initialized after it is turned on, which includes checking the cache and configuring the network. Remind users to connect to an available network if the network is unavailable. If the network configuration is successful, the system starts to read the node list, send the online information, and complete the joining network. The user can then call the message transmission module to communicate.

2.3 Network settings
After the application is launched, the system checks the current network configuration, as shown in Figure 3. If there is no Wi-Fi network connection, enter the network settings interface. If the network connection is successful, the system searches for nearby peers and rendezvous points, reads the peer list information on the rendezvous point, and sends an online message. At this time, the user has joined the D2D network and can communicate with other users.

2.4 Peer discovery
Peer discovery is implemented using the Peer Discovery Protocol (PDP). Under JXTA, Advertisement is the basic unit of various information exchanges between Peer. It is found that the problems of finding other Peer and its resources are converted into the problem of discovering the Advertisement of each resource. As long as the corresponding Advertisement is found, it is equivalent to finding the resource. The PDP defines a protocol for discovering other peers and resources. The protocol includes two aspects, one for requesting the advertisement of other peers, and the other for responding to such requests from other peers.

The defined peers in JXTA are included in at least one group, so when the system starts, you need to join a public group to get the services provided by the system. When searching for a node, as shown in Figure 4, the original node(B) sends a search request to the neighboring peer(A). If there is no specific resource searched in the neighbor peer, the original node will send a search request to its rendezvous point RDV1. If the rendezvous point does not have the required advertisement information, it will issue a search request to the rendezvous points it knows (RDV2). If there is a required advertisement in the cache of a node (C or D), the node directly feeds the resource information back to the original node [8].
2.5 Network message transmission

Once the peers discover each other, JXTA can use a pipe to achieve direct communication between the two peers. JxtaBidiPipe is a two-way reliable communication pipe provided by the JXTA community. It uses error detection and packet loss retransmission mechanism to achieve bidirectional reliable transmission of messages. Two-way communication through the JxtaBidiPipe method requires two classes: JxtaServerPipe and JxtaBidiPipe. The JxtaBidiPipe class is completed for communication tasks. But the two sides need to establish this connection before communication, so the JxtaServerPipe class is used. The class first waits for a connection request. When someone asks for a connection, the two parties start to establish the actual two-way connection, that is, the JxtaBidiPipe class starts to generate and work. One of the two sides of the communication acts as a "server" and the other acts as a "client". When any party wants to send a message, it first encapsulates the message to be sent into a Message object, and then sends it through the statement: bidipipe.sendMessage(msg) to the other party.

Because the message is ready to arrive at any time, the reception must be asynchronous. Here you need to use the "message listener".

Specifically:
First, implement the message listener interface for both classes. The declaration of the class can be:
public class JxtaBidiPipeExample implements PipeMsgListener { }

Secondly, after implementing this listener interface, it is natural to implement a method:
public void pipeMsgEvent(PipeMsgEvent event) { }.This method is called automatically whenever a message arrives. So, how to deal with the received message, can be processed in this method. Specifically, there are generally two steps:
Message msg = event.getMessage() and
MessageElement msgElement = msg.getMessageElement( "MSG" ); [8]

Finally, the message content is obtained by the statement: msgElement.toString(), as shown in Figure 5.
3. Application of D2D Communication System on the Internet of Vehicles

In the future, to better realize the communication between the vehicle and the road, and between the vehicle and the vehicle, the vehicle self-organizing network (VANET) will play an important role. The vehicle self-organizing network is a special self-organizing network. It is an open communication network with automatic construction and uses vehicles and road infrastructure as information nodes. It has the characteristics of rapid and frequent network topology changes and short path life. If the vehicle self-organizing network is used as the medium of the D2D communication system, the vehicle can timely acquire relevant data of nearby driving vehicles, such as relative speed, distance, position, acceleration, etc., and transmit its information to other vehicles. With the change of the vehicle’s travel position and the surrounding vehicles, the network topology is continuously changed, the information is updated in real-time, and the surrounding emergency events are pre-judged, thereby realizing the applications of assisted driving, automatic driving, and anti-tailing of the vehicle.

For example, in a road section where congestion occurs, the vehicle will generate a congestion report, then the vehicle will inform other vehicles within a certain range (1000m) of the vehicle about its position and speed and the vehicle congestion in front, attention to slowdown, etc. [10] As shown in Fig. 6, the vehicle uses the road infrastructure as an information node to form a self-organizing network within a certain range. Through D2D communication, the vehicle can timely acquire relevant data of nearby driving vehicles, such as vehicle collision, lane change, and obstacles, etc. Reduce the number of accidents.

![Vehicle self-organizing network diagram](image)

**Figure 6. Vehicle self-organizing network diagram [11].**

4. Conclusion

This paper analyzes the current social road congestion, frequent traffic accidents, and other traffic problems, which leads to the development trend of the intelligent transportation system and its application Internet of Vehicles, and discusses the lack of spectrum resources that mobile communication must solve. A solution combining D2D technology with the mobile cellular networks is proposed, and a D2D system based on Android and JXTA is designed and implemented. The system level is mainly divided into three modules: network configuration, discovery node, and message transmission. Close-range users can communicate with D2D by joining the same network. Finally, the advantages of vehicle self-organizing networks are analyzed. The vehicle self-organizing network is proposed as the D2D system medium. Through the communication between vehicles under the same self-organizing network, the vehicle can timely acquire relevant data of nearby driving vehicles, thereby realizing a safe and reliable intelligent transportation system.
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