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Dissertation Title
A Method for Network Resources
Sharing of Mobile Devices

Submitted in partial fulfillment of the requirements for the admission to
the degree of Master of Science in Computer Science

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Abstract

With the rapid development of science and technology, more and more people can use their mobile phone in any place. Therefore, bandwidth of mobile devices becomes a hot research field nowadays. However, it still has many drawbacks in many cases, for instance, existing mobile phone bandwidth cannot meet the needs of users, and how to efficiently use idle resources around is very important.

The paper proposes an effective method to make use of idle network resources. This method is to use multiple mobile devices to create a wireless local area network. In the WLAN, mobile devices will share bandwidth with each other achieving the purpose of bandwidth aggregation. In order to verify the feasibility and performance of the method, the writer developed an android application. By experimental evaluation, the method proved to be effective and beneficial to solving the problem of idle network resources.

Keywords: wireless network, bandwidth aggregation, Wi-Fi Direct, mobile devices

Declaration

I declare that the report hereby submitted for the Master of Science degree at the University of Hong Kong is my own work and has not been previously submitted by me at another University for any degree. I cede copyright of the thesis in favor of the University of Hong Kong.

Acknowledgements

First and foremost, I would like to express my sincere gratitude to my supervisor Prof. F.C.M. Lau, for the continuous support of my project and research, for his patience, motivation and encouragement. Without his great help, I would not finish the project.

Besides my supervisor, I would like to thank my second examiner Dr. C. Wu for her hard questions, insightful comments and guidance.

Last but not least, I would like to thank my family, who always encourages me to pursue my career that I really loved.

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1. Introduction

1.1 Project Background

In recent years, with the continuous development of electronic information technology, bandwidth of mobile devices become a hot research field nowadays. In many cases, existing mobile phone bandwidth cannot meet the needs of users and how efficiently use idle resources arises people's huge concerns.

There are three conditions result the problem.

- With the continuous development of science and technology, mobile devices have become very popular around the world. Nowadays, the mobile network mainly includes 2G, 3G and LTE. In the majority of cities, mobile phone users still use 2G, 3G networks, and the prevalence rate of LTE is not very high. The speed of 2G/3G is not fast enough to meet people's needs.
- Although communication technology has made rapid progress, some video applications require a lot of bandwidth. People often like to use mobile devices to watch videos and listen to music, but bandwidth requirement of high-definition video is relatively large, and the download speed is relatively slow. Therefore, it is difficult for people to watch videos more convenient.
- Modern network technology still exists some bottlenecks. Because of the environmental impact, communication signal would become weak and can not support the huge demand of bandwidth, which will make bad effect on

the user's experience.

On the other hand, there are a lot of unused or idle devices can be find in the public places. People do not always use the mobile devices, resulting in waste of network resources. For instance, when someone is on the subway, he wants to browse the Internet using a mobile phone, but the network signal is poor. He would find that the people around him are with idle mobile devices. He would want to take advantage of these idle network resources. These unused devices can be used to accelerate his download speeds.

To solve the problem, the project aims to use the way of bandwidth aggregation to solve waste of idle network resources and weak motion signal.
The paper proposes an effective method to achieve the objective. The method is to install an application on the multiple mobile devices, and the application would use Wi-Fi Direct as the connection between mobile devices to share bandwidth with each other. That is to say, the user can make use of others devices' network to accelerate device of himself. By the new technology, the user would have a faster speed and a better user experience.

1.2 Organization of Report

This dissertation introduces the progress of how to complete the project. In brief, the paper mainly includes seven parts.

The first part introduces the background of the project. Existing mobile phone bandwidth cannot meet the needs of users to watch high quality videos and listen to music. So the writer proposed a new method to solve the problem of making use of idle network resources.

The second part introduces several different existing methods of bandwidth aggregation proposed. The writer finds relevant knowledge through the Internet and library, and studies lots of articles written by different scholars. These articles elaborate the relevant researches about the existing bandwidth aggregation or the speed of the mobile device. By studying these method, the writer designs an app to increase the download speed.

The third part introduces key technology. By comparing the Wi-Fi Direct and Bluetooth 4.0 technology, the writer find Wi-Fi-direct technology has more advantages than Bluetooth 4.0 technology. Therefore, the writer chooses Wi-Fi Direct technology to complete the project design.

The forth part introduces design and construction of system. The writer proposed a new method that an application would be installed in multiple mobile devices to use Wi-Fi Direct technology to create a wireless local area network. Within the WLAN, each mobile device can share bandwidth with each other and accelerate downloading speed.

The fifth part introduces the demo app. The main aim of demo app is to use another slave to accelerate http download speed of master. Master and slave use Wi-Fi Direct to connect with each other. In order to verify the feasibility of the entire project, the writer designed and made a presentation using the app to realize

the basic functions.

The sixth part introduces the analysis and evaluation of the application. The writer chose three different file to test the download speed of “Single Download” and “double download” mode. By analyzing the experiments data, the writer concludes the strengths and weaknesses by the progress of completing the design.

The seventh part is the conclusion which concludes the entire demo app design and evaluation. This app is proved can increase the download speed.

2. Existing Method

Nowadays, there are several different existing methods of bandwidth aggregation proposed.

To the best of our knowledge, there are some approaches on bandwidth aggregation on one single mobile phone through using Wi-Fi and 3G/LTE interface simultaneously [1][4]. And there is a way of network acceleration via offloading on a specific proxy server. Some approaches proposed to use a hardware equipment to increase the speed of mobile phone around [8].

But until now, there isn't an app achieving the function, which can aggregate bandwidth of mobile devices and share the resource. So this research has a significant influence.

The method which the writer proposed does not introduce any intermediate hardware or require changes to current applications or phone system.

The project draws some ideas of cloud computing, there are no additional modification on mobile device's operating system and it does not require any additional hardware investment on the proxy server, user just needs to install the application on the mobile device, and the application can expand bandwidth using the idle network resource of others.

3. Key Technology

There are two choices to connect mobile devices without Internet: Wi-Fi Direct and Bluetooth 4.0. By comparing the advantages and disadvantages between Wi-Fi Direct and Bluetooth 4.0 technology, the writer find Wi-Fi Direct technology has more strengths, so the writer chooses Wi-Fi Direct technology to complete the project design.

Originally, the writer wanted to use Bluetooth 4.0 to connect the network, so the writer had studied some researches and books about Bluetooth. The Bluetooth is fully developed technology and can be easily used in mobile devices. Although it has a series of advantages, such as low power cost, but the speed limit is a huge drawback. The High-speed model of that is 24 Mbps (not enough fast) and it also needs some Wi-Fi hardware supports. However, Wi-Fi Direct can be as high as 250 Mbps. As a result, the writer chose the Wi-Fi Direct technology which is the opponent of Bluetooth 4.0. The new version of android system includes the Wi-Fi Direct technology, which allows devices with the appropriate hardware to connect directly to each other via Wi-Fi without an intermediate access point.

3.1 Definition of Wi-Fi Direct

In October 2010, Wi-Fi Alliance released the white paper of the new technology called Wi-Fi Direct. The white paper describes the basic information about

features and functionality of this technology. Wi-Fi Direct standard refers to allow wireless devices in the network without having to be connected to each other through a wireless router. Similar to Bluetooth technology, this standard allows wireless devices to form interconnection point, and in terms of transmission speed and transmission distance is a substantial upgrade over Bluetooth.

Wi-Fi Direct technology is a Wi-Fi standard which enables electronic devices to connect with other electronic devices without requiring a wireless access point, and the process will become more easy and convenient. It is usable for everything from internet browsing to file transfer, and to communicate with more than one device simultaneously at typical Wi-Fi speeds. One advantage of Wi-Fi Direct is the ability to connect devices even if they are from different manufacturers. Only one of the Wi-Fi devices needs to be compliant with Wi-Fi Direct to establish a peer-to-peer connection that transfers data directly between them with greatly reduced setup.

Wi-Fi Direct negotiates the link with a Wi-Fi protected setup system that assigns each device a limited wireless access point. Wi-Fi Direct devices can be set up to require the proximity of a near field communication, a Bluetooth signal, or a button press on one or all the devices. Wi-Fi Direct technology may not only replace the need for routers, but also replace the need of Bluetooth.

Wi-Fi Direct essentially is a software access point which can be installed into any electronic devices. The soft AP provides a version of Wi-Fi Protected Setup with its push-button or PIN-based setup.

When a device enters the range of the Wi-Fi Direct host, it can be connected

automatically. Then the device can gather setup information using a Protected Setup-style transfer. Connection and setup is so simplified that some suggest it may replace Bluetooth in many situations.

Soft APPs can be as simple or as complex as the role requires. A digital picture frame might provide only the most basic services needed to allow digital cameras to connect and upload images. A mobile phone can allow data tethering might run a more complex soft AP that adds the ability to connect into the Internet. The standard also includes WPA2 security and features to control access within corporate networks. Wi-Fi Direct-certified devices can connect one-to-one or one-to-many and not all connected products need to be Wi-Fi Direct-certified. One Wi-Fi Direct enabled device can connect to legacy Wi-Fi certified devices.

3.2 Advantages of Wi-Fi Direct

Wi-Fi-direct technology has three main advantages, including mobility and portability, instant availability and ease of use.

3.2.1 Mobility and Portability

Wi-Fi Direct devices can be connected to each other in anytime and at any place. Since no Wi-Fi router or access point is required, the Wi-Fi device can be implemented at any place.

3.2.2 Instant Availability

Users will be able to use the first Direct Wi-Fi authentication device to establish a

direct connection with the home. For example, a newly purchased Direct Wi-Fi notebook can be directly connected with the user's existing traditional Wi-Fi devices.

3.2.3 Ease of Use

Direct Wi-Fi device discovery and service discovery functionality to help users determine the availability of equipment and services, and then establish the connection.

Simple and safe connection: Wi-Fi direct devices using Wi-Fi protected setup it simplifies the process of creating safe connection between devices. The user can press any device on the button, and then enter the PIN code, easy to create a secure connection.

4. System Design

The paper proposed a method that an application is installed in multiple mobile devices to use Wi-Fi Direct to create a wireless local area network. Within the WLAN, each mobile device can share bandwidth with each other and accelerate downloading speed.

4.1 System Composition

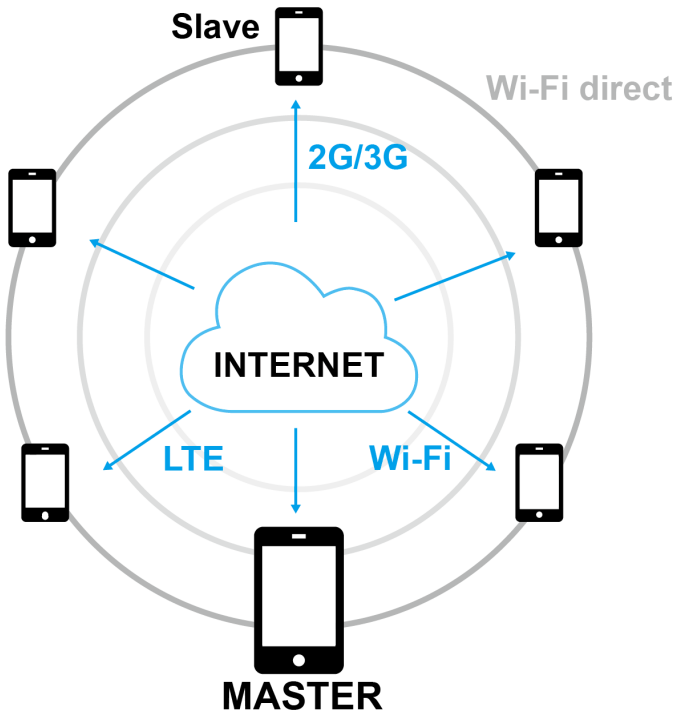


Figure 4.1: System composition

This entire system consists of several parts:

User: Mobile device holder who uses the device to surf the Internet.

Master: The mobile device used to surf the Internet or watch video is called master. Master may have low speed network connection or require much more bandwidth than its has.

Slave: The idle mobile device is called slave. They can connect to Internet with a lager bandwidth.

Application: Software installed on the mobile devices is the main part of system.

Internet channel: Internet channel includes 2G/3G/LTE/Wi-Fi network.

3G/LTE channel: It is used to download files from the internet channel.

Wi-Fi direct channel: It is used to transfer information and files between mobile devices without Internet connection.

4.2 System Structure

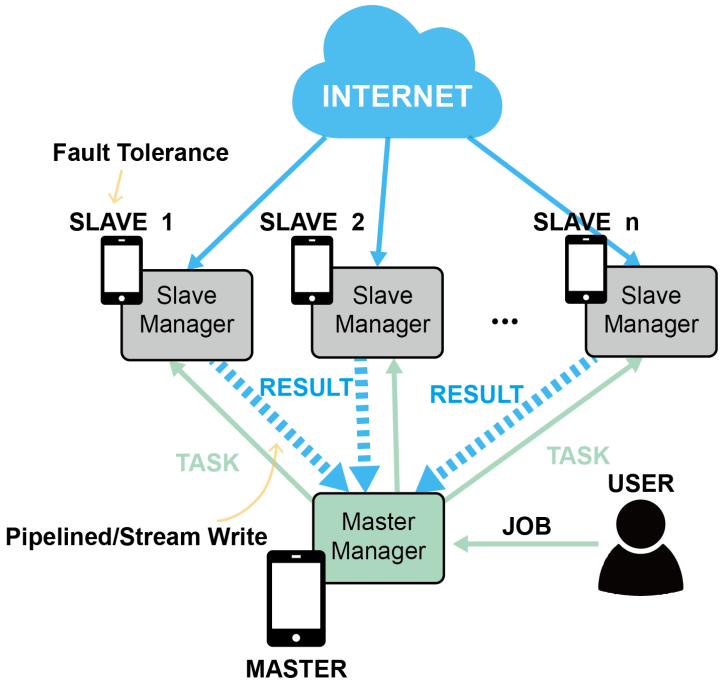


Figure 4.2: System structure

4.2.1 Application

The specific application can connect mobile devices together, execute user's job, and transmit the task to slaves. When slaves receive the request, they can execute its own task and transmit the results to the master. Management parts of the software draws on the concept of cloud computing and Hadoop. The application consists of two main parts: master manager and slave manager.

4.2.2 Job

The user wants to surf the Internet such as watch video or download files. These requirements are called job. User sends the job to the master manager installed on the mobile device. According to different user's job such as http downloading/FTP/ Streaming Media, the master manager uses different methods.

4.2.3 Task

The Job can be divided into many small tasks; these tasks are executed on the slaves.

4.2.4 Master manager

This section should take a specific way to divide a job into many tasks according to type of job, and decide which task to send to which mobile device according to network condition.

The method contains an adaptive mechanism of scheduling the transmission tasks. An optimal method schedules the transmission tasks for multiple devices

according to bandwidth condition. So that it can get the best efficiency.

4.2.5 Slave manager

This section is used to manage running tasks on the slave. Each slave can run many different tasks. If the task crashes, it will send message to tell master manager which task has crashed, and the master manager will reassign it.

4.3 Optimization Mechanism

4.3.1 Fault Tolerance

This concept comes from Hadoop. Over a period of time, slave will send a message to master, if the master received this message, it would know the slave is working properly. If master do not receive this message over 3 times, it would think that slave may appear certain issues, such as the app on the slave is closed or the salve moves far from the master.

If a slave is lost, it will be removed from the network, and the master will reassign the task to another device again. If a task crashes, retry on another node. If the same task fails repeatedly, fail the Job.

4.3.2 Pipelined Write/ Stream Write

For consideration of efficiency, there are two ways to choose when the result sent back to Master. The first way is pipelined write that each slave's result should be divided into small segments, so that the segments can be sent to the master while the downloading is still in progress. The second way is stream write that the result

should be transformed into stream data. Pipelined write is more reliable but stream write is faster.

4.4 User Experience

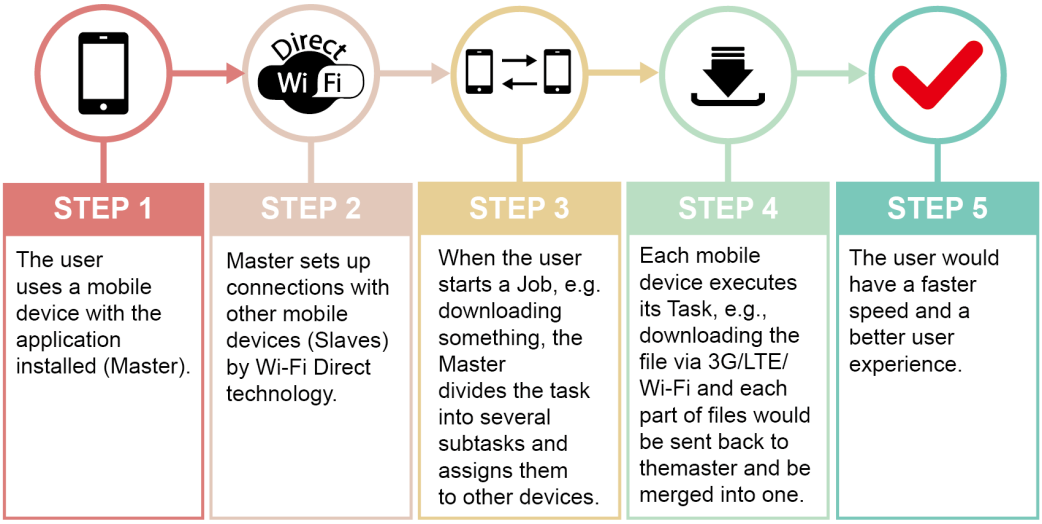


Figure 4.3: Usage process

Firstly, the user uses a mobile device with the application installed and choose the master mode. Then the application would set up connections between Master and Slaves by Wi-Fi Direct technology. When the user starts a downloading task, the Master divides the task into several subtasks and assigns them to other devices and master itself. Then each mobile device executes its download tasks. And each part of files would be sent back to the master and be merged into one. Finally, the user would have a faster speed and a better user experience.

5. Demo App

In order to verify the feasibility and performance of the entire method, the writer designed a demo app to do some experiments. Android platform was chosen for development, because android is open source, and development cost is relatively cheap, saving research funding.

Unfortunately, because of the time and technical issues, this app does not implement all the features mentioned in this paper, only achieving the basic functions.

5.1 Main Function

The main aim of demo app is to use another slave to accelerate http download speed of master. Master and slave use Wi-Fi Direct to connect with each other. Master wants to download large files using URL, but its bandwidth is not enough. Firstly, master asks the Internet server and gets the size of the file, and assigns the range on average. Then it sends the URL and file range to the slave. Master and slave both only need to download half of the file for the Internet. When slave has downloaded half part of the file, it would send the file back to the master using Wi-Fi Direct channel. Master then combines these parts of files into one complete file.

5.2 Software Introduction

5.2.1 Main User Interface

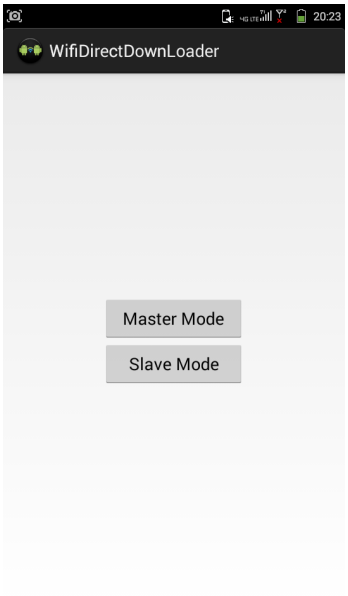


Figure 5.1: Main UI

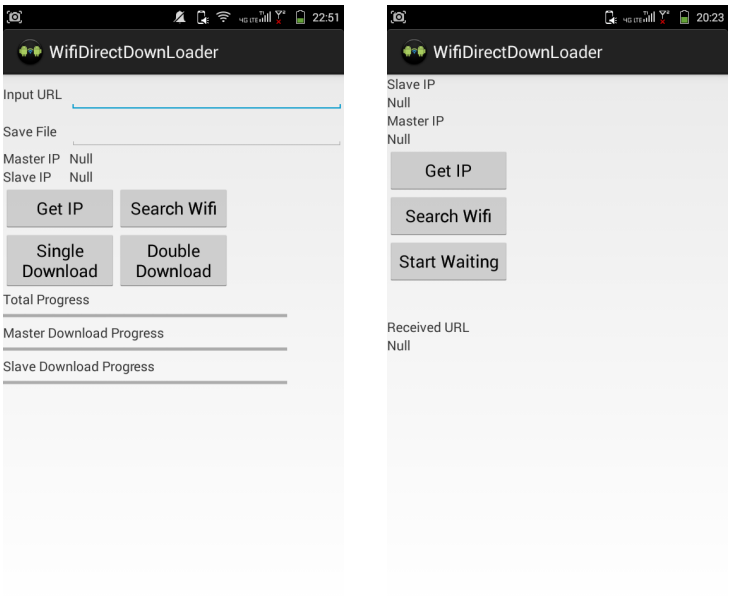


Figure 5.2: Master UI and Slave UI

When the Demo is launched, the main user interface will show on the screen. There are two buttons on the main user interface. If the “Master Mode” button is clicked, the device will play the role of master, and master UI will show on the screen. Also, if the “Slave Mode” button is clicked, the device will play the role of slave and slave UI will show on the screen.

5.2.2 Master Mode

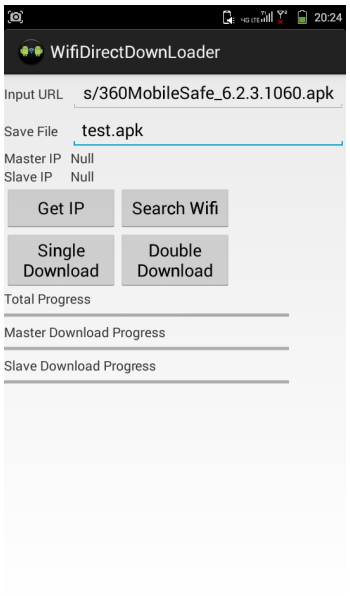


Figure 5.3: detail of mater mode

“Input URL” is the place to input the URL of download file, and “Save File” is the place to input the file name of download file.

“Search Wi-Fi” button is to set up Wi-Fi direct connect between master and slave.

“Get IP” button is get the IP address of the master and slave.

“Single Download” and “Double Download” button is to chose the download

mode for the master.

Also, there are three progress bar to show the progress of the downloading file.

5.2.3 Slave Mode

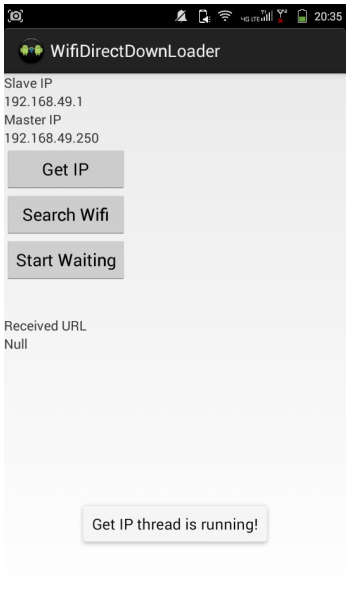


Figure 5.4: detail of slave mode

"Search Wi-Fi" and "Get IP" button in the slave mode is the same as the master mode. And when "Get IP" is clicked, the IP address will show on the screen.

"Start Waiting" button is for the slave to wait the command from the master. After master and slave connect successfully, "Start Waiting" button should be clicked, and then the master can choose the download mode.

When slave receives the URL form the master, it will show on the screen.

5.2.4 Multi-machine Download

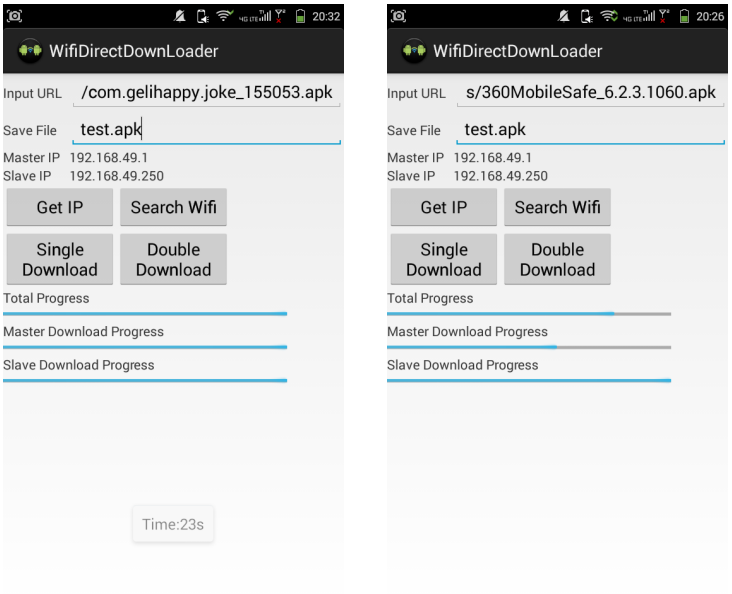


Figure 5.5: Multi-machine download mode

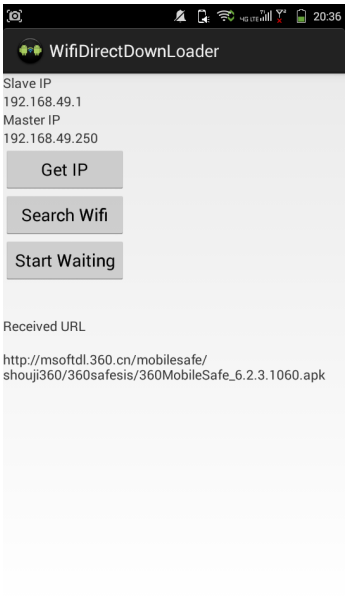


Figure 5.6: Time cost message of “Double Download”

When click “Double download” button, the master will ask server about file size, then assign ranges to slave and itself on average, then send URL and range

information to slave. After receiving information, slave will automatically download file, then transmit file back to master. Master then combine these files into one complete file. When master completed, a message appears telling the file has been downloaded and the time cost.

5.2.5 Stand-alone Download

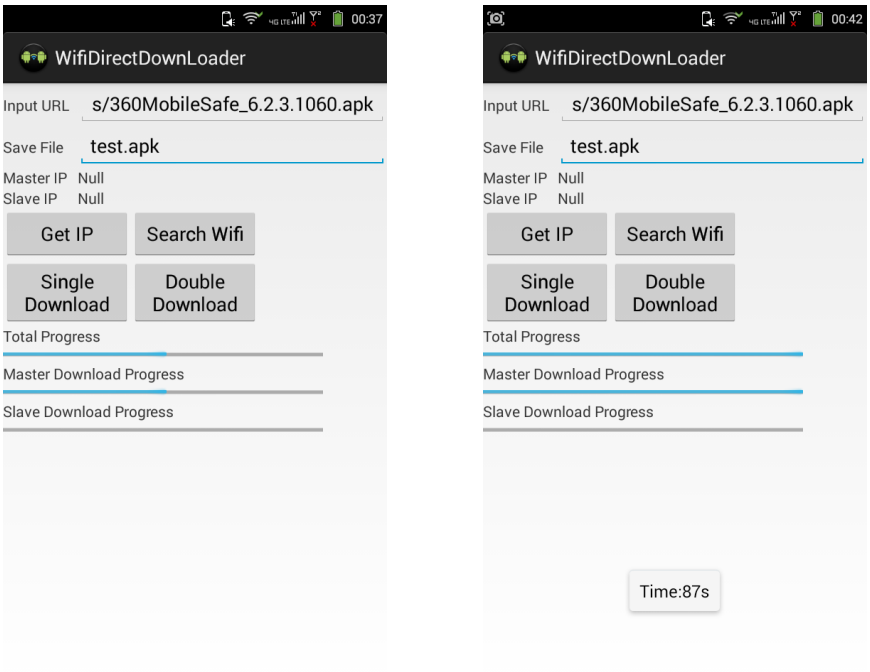


Figure 5.7: Stand-alone download mode & Time cost message

When click “Single download” button, the master will download file from the Internet using http download all by itself and save the file on SD card. When master completed, a message appears telling the file has been downloaded and the time cost. The time can be used to compare with the time cost in “Double Download” mode.

6. Evaluation

6.1 Experiment for Demo App

The writer chose three different file to test the download speed of "Single Download" and "double download" mode.

Num	File1(9Mbytes)		File2(20Mbytes)		File3(Mbytes)	
	Single Download Time(s)	Double Download Time(s)	Single Download Time(s)	Double Download Time(s)	Single Download Time(s)	Double Download Time(s)
1	72	33	144	83	212	103
2	68	34	148	89	226	105
3	66	40	153	88	228	139
4	71	40	156	90	230	138
5	73	43	180	91	210	141
6	75	42	139	86	243	148
7	74	34	145	81	241	146
8	60	30	129	73	240	121
9	61	37	138	69	246	137
10	57	40	137	87	228	127
Average	67.7	37.3	146.9	83.7	230.4	130.5
Speed Up	81.50%		75.51%		76.56%	

Table 6.1: Experiment result

This simple demo app cannot assign tasks to slave according to network bandwidth. It only can assign tasks on average. Lack of this optimization mechanism makes the demo app can not show all the great advantages of the proposed scheme.

Even though there are some negative factors, the result of the experiments shows that download speed under the two devices is increased by about 80%, and save time by about 45%. So the demo App also shows the proposed method has a great effect. The method proved to be effective and beneficial to solving the problem of

idle network resources.

6.2 Future Work

1. Add the task assignment and fault tolerance mechanisms, so that the application can can better reflect the performance of the method proposed.

2. Make the application available to more devices.

3. Develop the specific app for different operating system, such as iOS, window phone and so on.

4. To improve the performance of the proposed method, more optimization mechanisms should be added.

7. Conclusion

With the continuous development of network information technology, everyone has electronic devices such as cell phones. When people in some public place such as bus stations or other places, they often watch high-quality video or surf the Internet, but the speed limit caused bad user's experience.

So the writer proposes a method to make use of idle network resources. This method is to use multiple mobile devices to create a wireless local area network and in the WLAN, mobile devices will share bandwidth with each other.

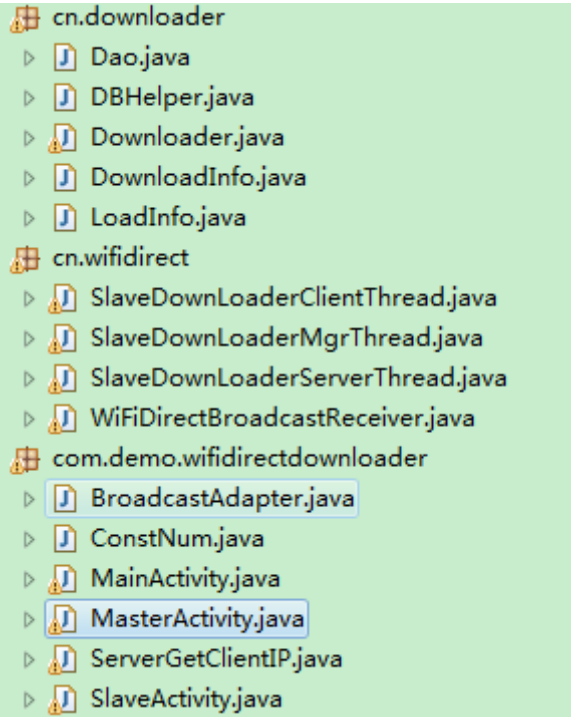
The method does not introduce any intermediate hardware or require changes to current phone system. User just needs to install the application on the mobile device.

In order to test the performance of the method, the writer develop an android demo app to test the actual performance.

And the result of the experiments shows that the app can greatly accelerate download speed because download speed is increased by about 80% and time is saved by about 45%. So the method proved to be effective and beneficial to solving the problem. The method proposed is simple, convenient, low cost, etc., to achieve a reasonable allocation of network resources.

Appendices

Main Java Class Introduction



cn. downloader: This package mainly realizes the function of http downloading.

- public class Dao: This class is to control data stock, the main controls contain search, update, insert and delete data.
- class DBHelper: This class is mainly to build a data stock which can reserve the rate of files progress.
- public class Downloader: The class can realize the function of downloading. data of stock. Parameter “typeDownload” can decide use stand-alone download mode or multi-machine download mode.

- public class DownloadInfo: This class as same as public class LoadInfo, the difference is that this class is to save the running thread download data.
- public class LoadInfo: This class is to reserve the data structure of download information, and the main function is to transfer the stock's data.

cn. wifidirect: This package mainly realizes the function of Wi-Fi Direct.

- SlaveDownLoaderClientThread: This is the slave's download thread which launched by SlaveDownLoaderMgrThread. These need to launch three threads totally.
- SlaveDownLoaderMgrThread: This is download manager. Parameter "DownLoaderMgrType" can decide it becoming master or slave.
- SlaveDownLoaderServerThread: This is master's download thread which can receive the download date sent back from slave. These need to launch three threads totally.
- WiFiDirectBroadcastReceiver: This is a Broadcast Receiver which mainly receives the information of Wi-Fi Direct, then let Activity to deal with.

com. demo. wifidirectdownloader:

- public interface BroadcastAdapter: This is a simple interface which can make master and slave can be use by Activity. What's more, the master and slave can realize this interface.
- public class ConstNum: Every Id can be defined in this class.
- public class MainActivity: This is the first user interface, and there are just

only two simple buttons on it.

- public class MasterActivity: The class of master can realize the master's logic, and it concludes the Wi-Fi direct initialization, connecting, accessing slave 's IP, laughing the stand-alone down or multi-machine download and so on.
- public class ServerGetClientIP: This class aims to access the IP address. When Wi-Fi Direct connects successfully, only group owner’s IP address is known by both sides, and group members need to ask for a connect from master so that the master can know the group members IP and can build stock.
- public class SlaveActivity: The class of slave is as same as the function of master.

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