Gesture-based Image Acquisition between Smartphone and Digital Signage

by

Jason Ching-Hsien Ho

A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of
Master of Mathematics
in
Computer Science

Waterloo, Ontario, Canada, 2011

Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Mobile phones have formed a social network within the phone subscriber population by allowing the phone subscribers to exchange information. Nowadays, smartphones have been improved with a variety of functionalities, such as a built-in cameras, motion sensors, and Wi-Fi wireless connectivity to enable the phone subscriber to take photographs of a desired object for distribution to other users through SMS or email. These functionalities make the mobile phones the perfect tool in terms of viral marketing within cellular phone subscribers.

This thesis proposes a novel methodology that allows the phone subscriber to perform gestures for image acquisition from public signage displays. The public display is signage which displays a list of images in chronological order. The signage distributes the image list to nearby phones in the form of datagrams by means of multi-casts. Additionally, Wi-Fi connection between the phone and the signage must be established to enable multi-cast. When the phone has the completed image list downloaded, the phone subscriber can point the phone at the signage and perform a dragging gesture once he sees the desired image displayed by the signage. The current state of the project has concluded the development of the application to achieve the aforementioned task. However, the development of data transmission from one phone to another is still ongoing. Further development in the future would enable another gesture for data distribution to other phones in the vicinity.

Web-based administration applications have also been developed to manage the image list in the signage. Through this web-based application, the administrator can generate new image list and then upload it to a FTP server. When the updated image list is stored in a remote FTP server, the signage periodically retrieves the image list from the FTP server. After the signage has received the updated image list, it then distributes the image list in the form of datagrams by means of multicasts. In summary, this thesis documents the impact of such technology in viral marketing research.

Acknowledgements

Since starting at the University of Waterloo, many of my lifelong lessons were taught by individuals who are probably unaware of their impressions on me over the two year graduate program.

First at all, I would like to express the deepest appreciation and gratitude to my supervisor Prof. Pin-Han Ho, who has provided his exceptional insight and consultation in the development of my research interests. He has positively influenced me in many ways and has always been available for both social and academic counsel throughout my graduate years.

I would especially like to acknowledge Dr. James She, who has been invaluable as a mentor. This thesis is based upon on work that I have done when I was working under him in the University of Cambridge, and only with his dedication, wisdom, and inspiration, could I have completed everything on time.

Finally, I would like to thank: Jaimal, Kevin, Rajiv, Tariq for keeping me entertained and living healthy; Christie for supporting me in the process of thesis writing; my brother, James, for encouraging me to come back to school and sharing his academic experience; most importantly, my Father and Mother for their sacrifices.

Table of Contents

List of Figures

List of Tables

Chapter 1
Introduction

Nowadays, people absorb advertising trends from public signs while walking down the street. Although advertisements have existed since ancient times, the method of printed posters has not been subjected to advancements of technology. In the rapid transition of information among society today, it is absolutely necessary for the existing static poster displays to change to multimedia advertisements that allow interactions with society. Existing methods of advertisement require a person to memorize the displayed information. This remains an obsolete method since the brain may forget the information, a written down note might be forgotten, and the information cannot be transferred to the person's network easily.

1.1 Existing Technology and Limitations

Since the smartphone has penetrated widespread acceptance in the general population, advertisement technology can utilize the smartphone hardware and software capabilities to acquire information. A smartphone possesses the advantages of Wi-Fi, Bluetooth, and infrared connectivity, making it possible to interact with displays located within sight. While it is possible to capture a photograph of the advertisement, the digital image remains stored only on the phone subscriber's handset. With the proposed technology in this thesis, digital signage will capture the interest of the audience and using natural gestures, the information can be transmitted to multiple social media networks reaching a much larger audience. The strength of passing information from an interested person through to their mobile online social media and networks is the identification of a niche market that would otherwise require individual advertisement approach.

1.2 Contributions

This thesis is based on the system and architecture developed by Dr. James She, who has originated the basic concept of the Smart Signage Project. This thesis is characterized by a number of contributions towards both advertisement providers and the advertisement viewer. The proposed framework does not only the display still image advertisement; it also broadcasts digitalized information. While the conventional signage only displays advertisement to try to catch people's attention to make them remember the information within the advertisement, the digital signage in this

framework distributes digitalized information in the wireless network of the signage installation location. The digitalized information can be caught by smartphones with a client-end application installed, and, thus, anyone within the area of the signage coverage can be exposed by the information broadcasted by the signage.

The client-end phone application provides an innovative feature to allow the phone subscriber easier way to acquire information. The information acquiring function is gesture-based instead of touch-based. As the phone subscriber notices the presence of the digitalized signage, he can acquire the information from the signage by pointing the signage with his phone and then performing the dragging gesture. This method to acquire information is more intuitive in comparison to other touch-based applications, where the phone subscriber has to see the phone screen and be sure to push the right button to operate the application. Since the phone subscriber's attention is caught by the content in the signage when he sees one, gesture-based applications, such as the one introduced here needs less phone subscriber's attention on application operation than touch-based applications.

In the future work of the Smart Signage Project, the client-end phone application will provide phone-to-phone information sharing functions. This feature would contribute to the studying of viral marketing greatly, because the digital information is spread out in the phone subscriber’s social network. Thus, people can receive the digital information from their friends even though they are out of the signal coverage of the signage. Again, the phone-to-phone information sharing will be a gesture-based feature where the phone subscriber can select the digital information on his phone, perform the gesture to the nearby smartphones, and then the nearby smartphone will receive a notification to choose whether or not to accept the incoming digital information.

The rest of the thesis is organized as follows. Chapter 2 provides the background knowledge such as the basic network layout and players involved in the project. Chapter 3 covers the signage-related material in the project, and it talks about the signage components, the signage administration tool, and the physical installation. Chapter 4 gives instruction on how to use the phone application to interact with the signage and an overview of additional functionalities in the phone application. Chapter 5 shows experimental results with multi-signage setup and what can be done to improve the performance of the phone application. Finally, Chapter 6 brings the thesis to a closure with conclusive remarks.

Chapter 2
Smart Signage Project Background

This chapter presents the background knowledge of the Smart Signage Project. First of all, the research motivation and supplementary background information regarding the area of wireless viral delivery of mobile social media and networks are explored with similar technology. Secondly, the applications and stakeholders along with network architecture are explained for the clarity of ideas presented in this thesis.

2.1 Related Works

Nowadays, the mobile phone was been equipped with sensor, camera, and many other functions. Smartphones are now equipped with sensors such as accelerometers and gyroscopes, and these sensors enable the smartphones to measure movement. Thus, it is feasible to develop applications which allow the phone subscriber to interact with his phone by performing gestures. [CBCYKK2005] have proposed a gesture recognition system based on a tri-axis accelerometer embedded in the mobile device, and it was one of the earliest works to propose gesture-based interaction methods for the mobile device. In this paper, the mobile phone was able to recognize from numeric value from 1 to 9 and a few symbols written in the air. The phone subscriber can initiate command by shaking and then performing the gesture to operate applications installed in the mobile phone. In their work, Choi et al have claimed that they have achieved 97.01% of average recognition rate to gesture.

There are advanced phone applications which allow the phone subscriber to perform gesture with his phone to interact with remote devices. In [DB2008] and [DB2009], Dachselt et al have proposed a "Throw and Tilt" methodology to utilize sensors inside the smartphone to control a remote display device. The phone subscriber can perform a throw gesture toward a display device to upload all images to the remote display device, and then this device displays these images in bigger dimensions. The user can navigate and browse the images by tilting the smart phone. Several works have described using mobile device, such as smartphone, to receive information from a server wirelessly. [RMH2009] has proposed a technique for pedestrian navigation called the Rotating Compass. In the proposed framework, a public display providing individual navigation cues for different users, and then the users run a navigation application on their mobile phones to acquire information which is

being broadcasted by the public display. This navigation application can interact with the phone subscribers through vibrations when the phone subscribers are going to the correct directions. Very similar to the Smart Signage Project which will be introduced in this thesis, [MAL2010] has introduced iButterfly technology, which allows the phone subscriber to catch a virtual butterfly with his smartphone. After iButterfly is installed in the smartphone, the smartphone is able to detect the nearby iButterfly in the phone subscriber's current geographical location, and the phone subscriber can catch the butterfly and put it in his collection. Since there is no physical display to indicate the iButterfly in the location, the phone subscriber has to make sure that the iButerfly application is switched on all the time in order to detect the iButterfly.

In this thesis, the application in Smart Sigange Project can be applied in viral marketing. In terms of viral marketing, the media needs to be distributed from one individual to the rest of his social network. A number of works have proposed viral marketing methodologies and analysis in term of telecommunication and social network application on the Internet. Both [WHP2008] defined the term *mobile viral marketing* as a concept for distribution or communication that relies on phone subscribers to transmit content via mobile devices to other people in their social network. In this work, the content being distributed by the mobile devices is defined as *mobile viral content*. [WPP2008] studies the motivations, attitudes, and behaviours of the phone subscribers who receive and forward the mobile viral content in order to implement effective viral marketing. [KH2008] studied the online social networks, such as Facebook, to find the influencers who has wider social network and is able to distribute information effectively. [MMB2009] proposed a method to captures the true underlying network in the social network, and the true underlying network is supposed to spread the viral content efficiently in the social network. The above works are mainly giving theory and business model to persuade the readers that viral marketing is an efficient way to distribute commercial information in a social network.

2.2 Viral Marketing background

The emergence of social media marketing has grown since the earliest stages of blog entries, YouTube videos, Facebook updates, Twitter status outbursts, the geo-location tags and reaching a crescendo of possible marketing avenues unknown in any generation prior. To achieve a full picture of the social media fanbase, Coca-Cola has 23 million Facebook fans implicating that each of the followers will be able to receive updates and promotional material from the company. While Proctor

and Gamble Co.'s Pringles has 8.6 million fans, the visible wall contains visible wall posts from the brand. This allows brands to reach its intended target market and directly influence the peers of its market group in today's modern age. Following the early success of an exploding Mentos viral video amongst the internet four years ago, the Mentos brand has continued to maintain a strong social media impact. In 2010, Mentos mints had the majority of advertisements in social media and shopper marketing which resulted in a resounding increase of 6% to $72.8 million for 52 weeks excluding the sales in Walmart and convenience stores [N2011].

The impact of viral marketing beckons a force that cannot be compared to traditional advertisement media of magazine spreads, billboards, and wrapped bus in our daily lives. The viral marketing within social media networks like YouTube, Facebook, Twitter, and Flickr demonstrate the strength of capturing the target market as it responds to the campaign. The postings instantly within real time reach audience members and their reaction is directly seen in increased memberships or liking status posts which were impossible in previous generations. It is imperative to foresee the reaction of the future generation of children reacting to anything less than attention getting and memorable advertisement campaigns that also transcend traditional media avenues. It is important for advertisement and marketing technologies to grow at an increasing rate to match the development of mobile phone technologies to capture a fair market share of users.

2.3 Large Display Advertisement Background

Large wall sized displays are predicted to become interactive advertising posters [2008KTOS]. For the potential of wall displays to become interactive media, two issues must be resolved. First, a means for users to input and interact in a user friendly method with the display must be devised. This must be an intuitive approach that supports real time recognition and is robust to environmental conditions. Currently, users have migrated from the traditional keyboard and mouse towards touch surface technology. Secondly, the transformation of information between the display and the intended user must be established. This linkage of data transmission will provide detailed information about the advertisement to the user and allow ease of access at a later time. The linkage can be established through wireless LAN, Bluetooth, Infrared or other ad-hoc methods of establishing a communication channel.

Research in the area of viral delivery using online mobile social media networks has been prevalent in recent years. Ventura et al have developed the Publix gaming system built on the freely available Bluetooth as a freely available and common feature among mobile phones supporting the multiple user interaction and ability to detect nearby mobile phones to interact with a matching game on billboard advertisements [VSJ2008]. The interactive display store front window developed at MIT's Media Lab responds to knocks of pedestrians [PLCH2002]. The developed system is based on the Bluetooth connection of nearby phones that detect a social media membership that allows proactive displays to share random pictures from the Flickr accounts of workforce colleagues [CHM2008]. This resulted in stronger personal friendships fostered at work. Based on the potential of public displays to interact with mobile phones, researchers Hard and Rukzio have discovered that pointing interactions of the phone capabilities work better than scroll interactions [HR2008].

A touch panel could be a candidate solution for interaction with the wall sized display. However, the larger the dimensions of the touch panels, the more expensive the cost of the panel and overhead operational equipment. The GestPoint method developed by GestureTek requires two cameras to locate a user hand to identify an object displayed within the wall [HM2008]. The GestPoint approach will only capture a two dimensional location perpendicular to the wall and does not recognize three dimensional movements or gestures. This limits the interaction to a very close proximity to the wall. Other software technologies and patents developed by GestureTek have been licensed for the use of the EyeToy made by Sony, XBOX 360 manufactured by Microsoft, ION Educational Gaming System made by Hasbro as well as in the mobile phones manufactured by NTT DoCoMo.

Researchers in Japan have further enhanced the GestPoint system to incorporate three additional modules: a mail client, a barcode generator, and a display client [2008KTOS]. The mail client allows a user to send an email with a specific address encoded 2-D barcode, that can be parsed to include a text part and the attachment. The attachment will be sent to the display module and the text represents the date, subject and body of the email written in Java Mail API. The barcode generator will contain the URL address with the attachment file saved as a QR Code generator. The QR code generator encodes the date, subject and body of the email to the display client. The last module, the display client, shows the attached images when the user selects it allowing the QR-code captured by mobile phones to obtain the URL address with detailed information saved on the phone. This allows a user to see the details of all the displayed icons on the large interactive bulletin board and for icon selection to occur without a physical finger touch. The information is then downloaded by the user to read the

barcode on their phone. This system supports simple gestures such as counting the number of fingertips but requires sufficient light condition to detect hand recognitions. The use of information transformation is secured through the 2-D barcode authentication but is not adequate for large sized data transfer such as movie files.

Last year, the online community bCODE offered a mobile coupon and ticketing service that support scans, coupon redemption, tracks unique digital coupons on mobile handsets and offers electronic tickets through mobile networks using the SMS method. The company offered an ease of use towards consumer facing services, security through a trusted electronic commerce platform, reliability of development that supports technology mobile commerce platforms, and real time data analytics for monitoring real time customer activity by location. The deployment of SMS/TEXT means that international users are supported, software limitations are overcome, and easy to use on any mobile device. There are already 4 billion users claimed on the webpage and the penetration rate among cell phone users are expected to be very high.

Table 2-1. Summary of Selected Papers by Primary Topic of Research

Related Paper			Technology Applied								
Reference	Author	Year	Wireless Method			Image Processor		Optical Sensor	Data Retrieved		
			Bluetooth	Wi-Fi	3G	QR	SMS	Gesture	Text	Image	Video
[VSJ2008]	Ventura et al	2008	Yes						Yes	Yes	
[PLCH2002]	Paradiso et al	2002	Yes							Yes	
[CHM2008]	Congleton et al.	2008							Yes	Yes	
[HR2008]	Hardy et al	2008	Yes						Yes	Yes	
[2008KTOS]	Koike et al	2008		Yes		Yes		Yes	Yes	Yes	
[DB2009]	Dachselt et al	2009		Yes				Yes	Yes	Yes	
[CFKRSS2005]	Cheverst et al	2005	Yes						Yes	Yes	
[YTHSH2006]	Yatani et al	2006	Yes					Yes	Yes	Yes	

2.4 Application and Stakeholders

In Smart Signage Project, there are two main applications under development namely Smart Signage phone application and Web Tool. Smart Signage phone application is the application installed in the

phone subscriber's smartphone and takes gestures as input to acquire or distribute digitalized information. At the current development stage, Smart Signage phone application is designed to work on smartphones running the Android Version 1.6 operating system. This phone application is more stable to run on the Google G1 smartphone. The second application in Smart Signage Project is a Web Tool, which is an administration tool for administrators to manage and configure the image playlist in the computerized signage. These two applications are developed and maintained by the administrator of Smart Signage Project.

Stakeholders are application users with specific role and assigned access right to applications developed in the project. The stakeholders in this project are namely the research administrator, the general administrator, and the phone subscriber. The research administrator has to develop both Smart Signage phone application and Web Tool, implements the signage installation, and uses Web Tool to configure the signage. In comparison to the role of research administrator, the general administrator is only responsible for one signage in the geographical area. The general administrators use a simplified version of Web Tool with limited access to manage the signage in his responsibility. The phone subscriber is the owner of the smartphone who operates Smart Signage Application by performing gestures with his smartphone in order to acquire or distribute the draggable advertisements. Through the entire thesis, these names of applications and stakeholders will be referred with the above definition.

2.5 Network Architecture

The Smart Signage communication network is composed of several elements, namely Web Tool workstation, FTP servers in the cloud, signages, and smartphones. The main propose of this communication network is to transmit draggables from the signage to the smartphone. A draggable is referred to the media that is being transmitted from the signage to the smartphone, consisting of an image and a file containing the information about this image.

This proposed communication network is a two-layered network architecture (Figure 2-1). The first layer is the signage which can access the FTP servers through wired or wireless Internet connections. The various way to access the Internet will be further elaborated in Chapter 3. The signage downloads the draggables update from the assigned FTP server every ten minutes. After the signage has finished downloading the draggable update, it uses multicast to transmit the draggable in datagrams. The

second layer consists of multiple smartphones with Smart Signage application installed. These smartphones are connected to the signage through Wi-Fi connections. The smartphone receives the datagrams from the signage when the Wi-Fi connection is established between the smartphone and the signage. As an additional feature of Smart Signage phone application in future development, the smartphone can establish peer-to-peer wireless connection with other smartphones in the vicinity in order to share draggables between two smartphones.

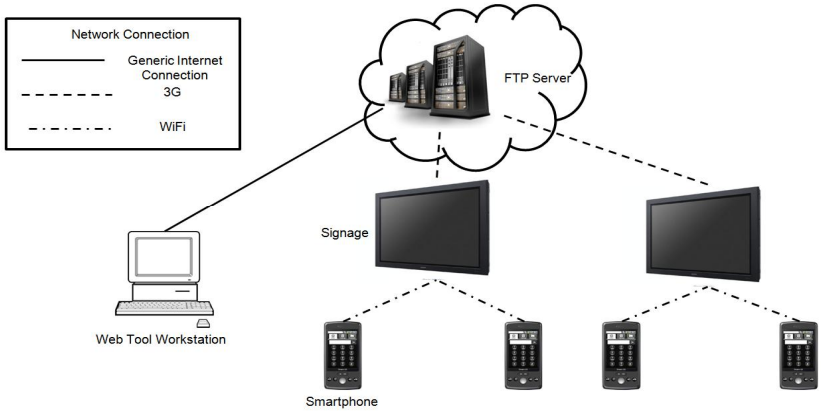


Figure 2-1. Proposed network architecture

The workstation with Web Tool installed is connected to the FTP servers in the cloud through a generic Internet connection. Through this workstation, the administrators can view the current draggable list of a specific signage, but also enables the administrator to generate and upload the draggable update to the FTP servers in the cloud. After the administrators have uploaded the draggable update to the FTP servers in the cloud, the signage needs Internet access in order to download the update from the FTP server. After the signage has downloaded the draggable update, the signage then sends out the draggable list in datagrams to the smartphone via multicast.

Chapter 3
Signage Implementation

This chapter is focus on the signage deployment and configuration. Section 3.1 gives an overview on Smart Signage network architecture, and methodologies of how information is transmitted within the network. Section 3.2 introduces Web Tool and its primary functionalities. Section 3.3 presents the signage hardware installation instruction and configuration.

3.1 Signage Components

The signage is a computerized display which shows a list of images in chronological order and sends out draggable by multicast. One signage station (Figure 3-1) consists of a monitor, a maxIPAD, router, a Wi-Fi USB dongle, and a 3G USB modem with a 3G SIM card inside. The monitor takes the images output from the maxIPAD as input and then displays these images. The monitor can be either Video Graphics Array (VGA) format or High-Definition Multimedia Interface (HDMI) format.

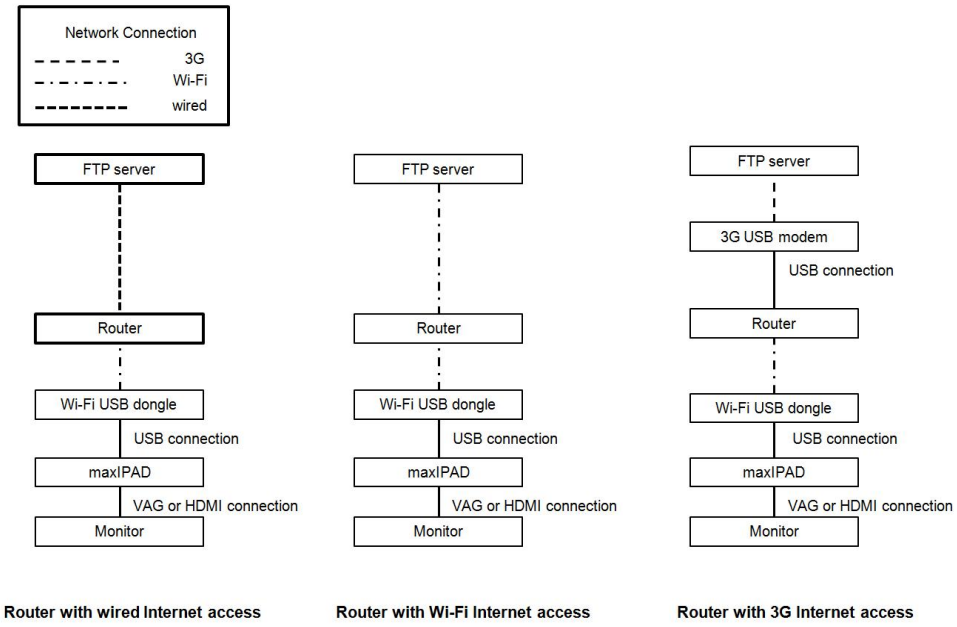


Figure 3-1. Basic signage setup with Different Internet connection

The maxIPAD is a simplified server which acts the brain of the signage by performing three tasks. The maxIPAD's first task is to store a playlist with a number of images and output these images to the

monitor. The second task is to transmit the images in datagram form to the router, so the router can perform multicast to transmit these datagram to the smartphones within the signal coverage. The third task is to periodically download playlist update from the remote FTP server through the router since the administrator always uploads the latest image list to the FTP server through the image administration application called Web Tool. Additionally, a Wi-Fi USB dongle is needed to connect to the maxIPAD to enable the maxIPAD to establish Wi-Fi connections to the router in the cloud.

There are three proposed methods to set router's Internet setting, namely wired connection (diagram on the left end in Figure 3-1), Wi-Fi connection (middle diagram in Figure 3-1), and 3G connection (diagram on the right end in Figure 3-1). If the installation location provides wired or wireless Wi-Fi Internet connection, the router can be set to access Internet through the existing Internet connections. In case that the location does not provide any form of Internet connection, the router can connect to the 3G USB modem to enable its 3G Internet connection functionality.

There are three kinds of playlist, namely the signage image list, and they each serve different proposes. These playlist are the thumbnail draggable list, and the text draggable list. All three playlists are uploaded to the maxIPAD by research administrators after they are generated.

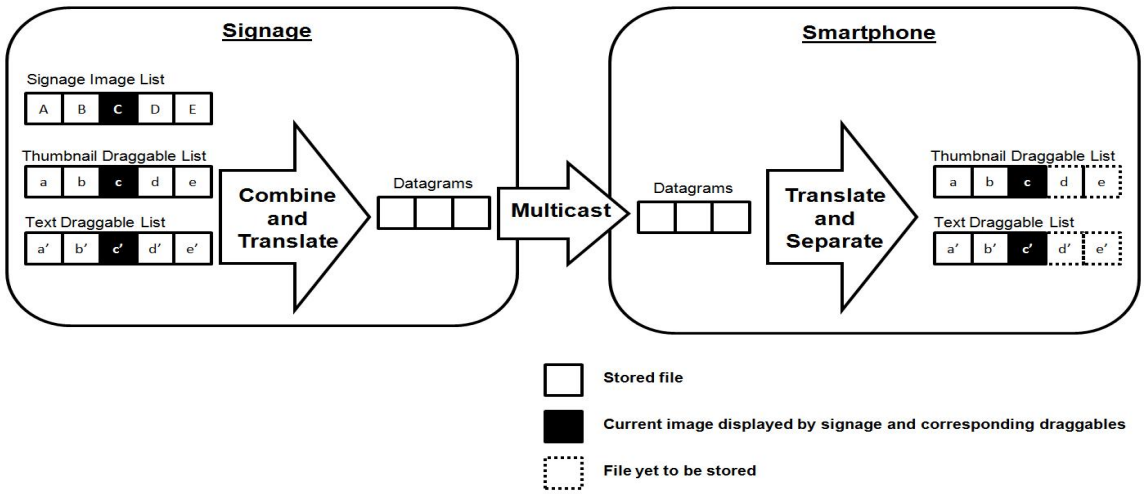


Figure 3-2. Draggable transmits from signage to smartphone via multicast

The signage image list is the actual playlist being output to the monitor for display. The image in the thumbnail draggable list is the same image representing the one in the signage image list, but it is smaller in file size. The file in the text draggable list is in an XML format, which contains

information about the particular image in the signage image list. When one image from the image list is displayed by the signage, the corresponding thumbnail draggable and text draggable are combined and broken down into datagrams by the signage, and then these datagrams are sent out to the smartphone by using multicast. When the smartphone receives the datagrams, it translates the datagrams to the thumbnail draggable list and the information draggable list. The necessary files of the playlists are generated by the Web Tool and the maxIPAD configuration application.

3.2 Web Tool

The Web Tool plays an important role for generating and managing the playlists. The Web Tool's primary feature is to allow the research administrator to generate the elements in the playlists. When an image is expected to be display in the signage, the research administrators can upload the desired image to the Web Tool, and then the Web Tool will generate the necessary files to be uploaded to the signage. When the Web Tool has finished generate the new files, the administrator can retrieve these files from the Web Tool and then upload these files to the signage and the FTP server.

The second feature is that the Web Tool allows the research administrators and general administrators to update the content of the image list for each signage. The administrators can view the current images in the playlists in the Web Tool and choose which image to update. When the research administrator selects one image in the playlist, the Web Tool prompts the administrator for the fields for the draggable elements update. After the draggable image and its information are updated on the FTP server, the signage can retrieve this update automatically.

Since the research administrators and the general administrators have different access rights to modify the playlists, two versions of Web Tool are built. The research administrator's Web Tool (Menu in the left side of the diagram in Figure 3-3) has the following main functionalities: *Create Media*; *Edit X Y Orientation*; *Projector*; *Existing Media at the Location*; and *Edit Media*. *Create Media* generates two versions of the same image for display on the signage and on the mobile device. *Edit X Y Orientation* uses the X-Y coordinate and renames the images created by *Create Media* accordingly. *Projector* is an application that simulates the behavior of the signage on a computer. *Existing Media at the Location* lists all images currently displayed by one specific signage. Finally, *Edit Media* allows administrators to replace an image in the current playlist with a new updated image for display on a specific signage. This version of the Web Tool gives the research administrator the

full access right to playlists of all signages in the Smart Signage Project, and it allows the research administrator to view and update playlists of all signages in this project. Comparing to the research administrator's Web Tool, the general administrator's Web Tool (Figure 3-4) has the only two functionalities: *Existing Media at the Location*; and *Edit Media*. This version of Web Tool allows the general administrator to view and update playlist of one signage in one geographical location which the general administrator is assigned for. The general administrator can only access the Web Tool of the signage in his responsibility, because a unique URL is assigned to each Web Tool. Thus, this makes the Web Tool more secure. The next several sub-sections are going to explain these functionalities in detail.

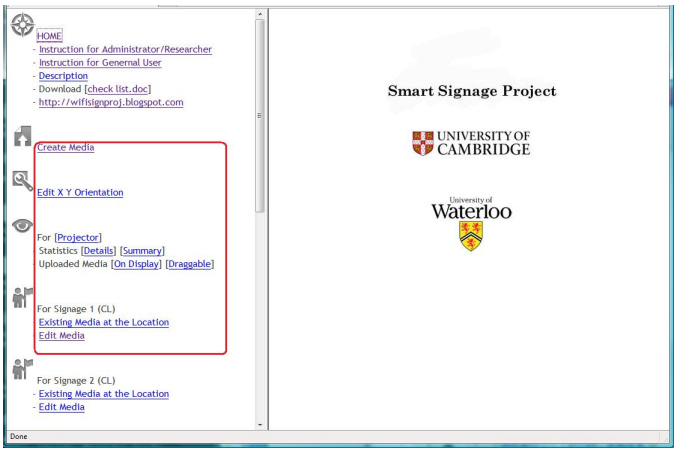


Figure 3-3. Research administrator's Web Tool user interface

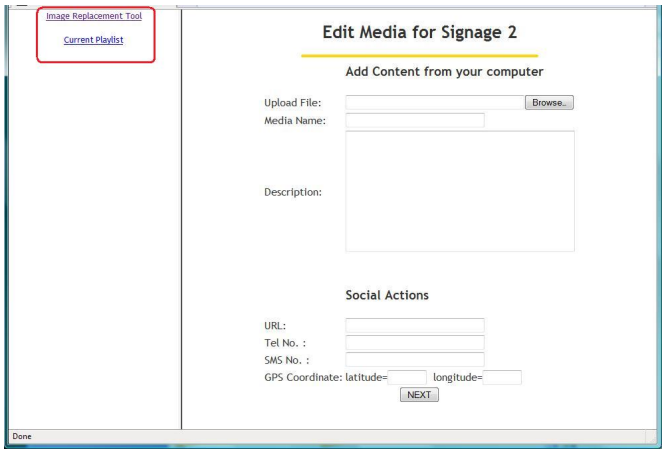


Figure 3-4. General administrator's Web Tool user interface

3.2.1 Create Media

In the initial signage setup, the research administrator is given a number of images to generate the new playlists, and he can upload these image and input necessary information on the Create Media form (Figure 3-5) to generate images and file for the new playlists. The Create Media function can be accessible by clicking the Create Media link in Web Tool's main menu (Figure 3-3). Then the research administrator is led to a form (Figure 3-5) consisting of two portions: *Add Content from Your Computer* (portion in the top square in Figure 3-5), and *Social Actions* (portion in the button square in Figure 3-5). This form allows the research administrator to upload an image and enter other text information about the image.

In the *Add Content from Your Computer* portion (top portion of the form in Figure 3-5) of the Create Media form, there are six prompts requiring input values. The Upload File text field requires a pathname input of the image to be uploaded. The *Media Name text* field requires a name to specify the image to be uploaded. The *Type* dropdown box needs a type to be selected for the image, and each type in the dropdown box has been assigned with a value which is needed to generate the URI in the filenames of the three new files. The *Signage Orientation* input is consisting of X and Y numeric inputs. The X and Y inputs are also needed to generate the names of the new files. The *Description* textbox needs text input of a short remark about the uploaded image.

Figure 3-5. Create Media Form (Part I)

In the *Social Actions* portion (bottom portion of the form in Figure 3-5), five prompts need to be filled out. This portion allows the research administrator to attach the social action information to the image to be uploaded. Currently, there are four *Social Actions*: *URL*, *Tel No*, *SMS No.*, and *GPS Coordinate* (latitude and longitude). The practical use of the social actions will be elaborated in Chapter 4. After the research administrator has finished inputting, he can proceed to the next page of the form by pressing the Upload button in the right button corner of the form.

After the research administrator presses the Upload button, the second page of this form appears (Figure 3-6). This portion allows the research administrator to upload the same image as the thumbnail image and choose a compress proportion. After Confirm button is pressed, Web Tool will generate three files namely display image, thumbnail draggable, and text draggable. The display image is the original image being uploaded, but it is renamed to URI_X_Y_s.jpg. The thumbnail draggable is the compressed version of the display image, and it is assigned to a name as URI_X_Y.jpg. The text draggable is a XML file containing most of the text information being inputted in the form (Figure 3.5), and it is assigned to a file name as URI_X_Y.xml. For the file name of each file type, X and Y are the values input to Signage Orientation in the form (Figure 3-5), and URI is a unique ID generated by the Web Tool. The research administrator can retrieve these three files from C:\apache-tomcat_6.0.29\webapps\ROOT\smartwebtool\FTP\ipad\Change\media folder, and then he can create the display images list, the thumbnail draggable list, and the information draggable list to upload to maxIPAD and the FTP server.

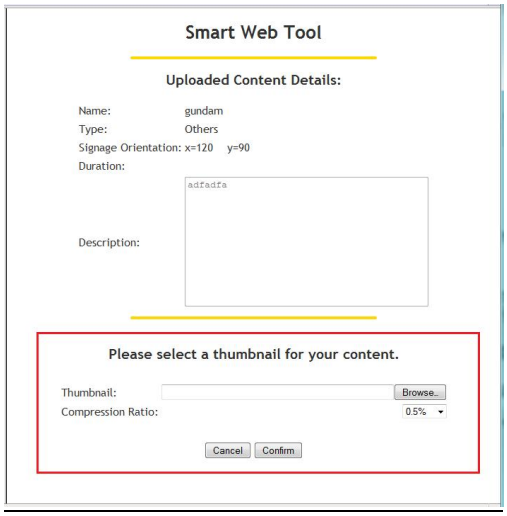


Figure 3-6. Create Media Form (Part II)

3.2.2 Edit X Y Orientation

The *Edit X Y Orientation* function allows the research administrator to modify the Signage Orientation (X and Y) of three files previously generated by the *Create Media* function. To access *Edit X Y Orientation*, the research administrator has to click on "*Edit X Y Orientation*" in Web Tool Main Menu (Figure 3-3), and then the research administrator is directed to a file list (Figure 3-7). The file lists shows list of showing images, thumbnail draggables, and text draggables generated by the Web Tool previously. The research administrator can tick the checkbox of these files which he wants to modify X and Y values of, enters the desired X and Y values, and then clicks on *Continue* button to perform the name modification. This function renames the files in C:\apache-tomcat-6.0.29\webapps\ROOT\smartwebtool\FTP\ipad\Change\media folder.

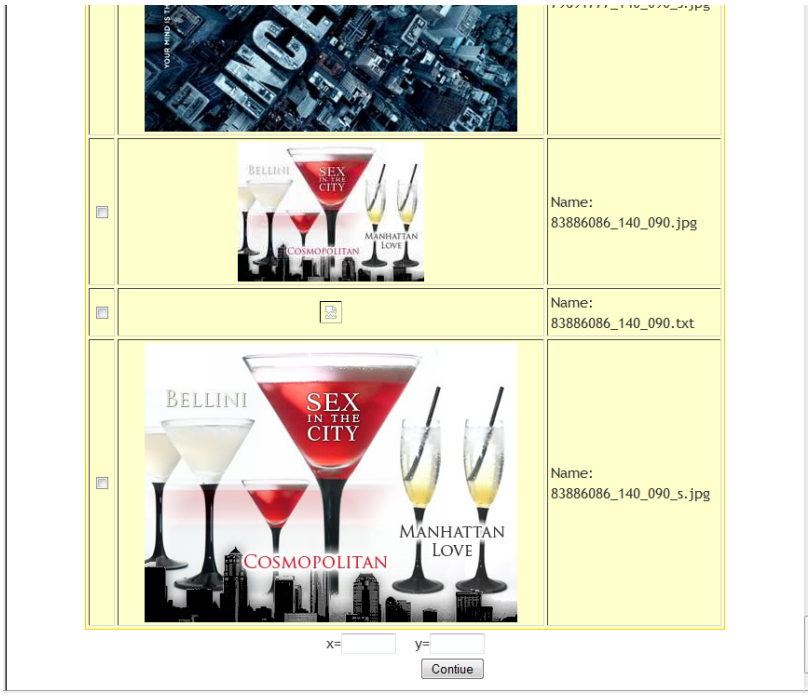


Figure 3-7. Lists of files in Edit X Y Orientation

3.2.3 Functions for General Administrator

The research administrator can access all the functionalities in the Web Tool (Figure 3-3) including the functionality in the general administrator's Web Tool (Figure 3-4). However, the general administrators cannot access these functionalities in the research administrator's Web Tool.

Since one general administrator is responsible of only one signage, the general administrator's Web Tool has limited functionalities to modify the playlists of the particular signage that he is responsible of. The *Existing Media at the Location* function (Figure 3-8) displays the display images in the image list of a specific signage.

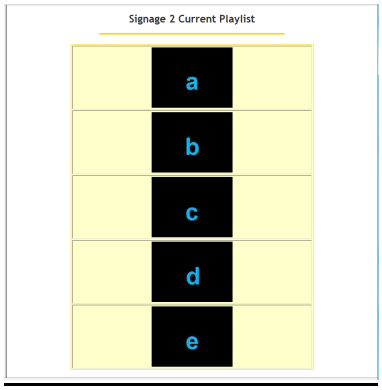


Figure 3-8. The Existing Media shows the current image list of particular signage

The *Edit Media* function (Figure 3-9) is accessible to both the research administrator and general administrator. This function is similar to the *Create Media* function (Figure 2-5), but it does not provide the *Type* and *Signage Orientation* fields, because modifying *Type* and *Signage Orientation* would modify the file naming and the general administrator does not have the right to change the files names. So, the general administrator is allowed to change the content of the draggable in the playlist, but he does not have the right to change the draggable's file name. The general administrator can press NEXT button after he filled up the fields in the form, and then he will be shown a current playlist in the signage. He can choose one image to apply the modification to.

Figure 3-9. Edit Media user interface

3.3 Physical Signage Installation

The signage installation and configuration is the responsibility of the research administrators. This section will illustrate the installation steps of the three methods since there are three methods (Figure 3-1) to set up router's Internet access. First at all, the following is the steps to set up signage with a wired Internet access:

A. If the monitor is in VGA format, plug its VGA cable to the VGA slot in the rear end of maxIPAD (Figure 3-10). If the monitor is in HDMI format, plug its HDMI cable to the HDMI slot in the rear end of maxIPAD.

B. Connect the Wi-Fi USB dongle to USB slot in the front end of maxIPAD (Figure 3-11).

C. Log on to the 3G router to assign it an SSID (Figure 3-13);

D. Plug Ethernet cable to the router's network cable slot for Internet access.

E. Generate maxIPAD configuration files by operating maxIPAD configuration software. These configuration files make the maxIPAD to display in chronological order and enable the maxIPAD to retrieve configuration files from specific FTP server through the router.

F. Save the configuration files and playlists to a USB drive and then upload these files to the maxIPAD though a USB drive.

G. Upload the configuration files and playlists to the FTP server. This configuration files in the FTP server are the default files to be replaced by the new set of configuration files which are uploaded by the research administrator, the general administrator in the future.

The following is the steps to set up signage with a Wi-Fi Internet access:

A. If the monitor is in VGA format, plug its VGA cable to the VGA slot in the rear end of maxIPAD (Figure 3-10). If the monitor is in HDMI format, plug its HDMI cable to the HDMI slot in the rear end of maxIPAD.

B. Connect the Wi-Fi USB dongle to USB slot in the front side of maxIPAD (Figure 3-11).

C. Log on to the router and configure it to connect to an assigned Wi-Fi network for Internet access, and assign the router an SSID.

D. Generate maxIPAD configuration files by operating maxIPAD configuration software. These configuration files make the maxIPAD to display in chronological order and enable the maxIPAD to retrieve configuration files from specific FTP server through the router.

E. Save the configuration files to a USB drive and then upload these files to the maxIPAD though a USB drive.

F. Upload the configuration files to the FTP server. This configuration files in the FTP server are the default files to be replaced by the new set of configuration files which are uploaded by the research administrator, the general administrator in the future.

The following steps are the initial installation of basic signage setup with 3G Internet access:

A. If the monitor is in VGA format, plug its VGA cable to the VGA slot in the rear end of maxIPAD (Figure 3-10). If the monitor is in HDMI format, plug its HDMI cable to the HDMI slot in the rear end of maxIPAD.

B. Connect the Wi-Fi USB dongle to USB slot in the front side of maxIPAD (Figure 3-11);

C. Connect the 3G USB modem, which contains a SIM card, to the 3G router's USB slot (Figure 3-12);

D. Log on to the 3G router to assign it an SSID (Figure 3-13);

E. Generate maxIPAD configuration files by operating maxIPAD configuration software. These configuration files make the maxIPAD to display in chronological order and enable the maxIPAD to retrieve configuration files from specific FTP server through the router.

F. Save the configuration files to a USB drive and then upload these files to the maxIPAD though a USB drive.

G. Upload the configuration files to the FTP server. This configuration files in the FTP server are the default files to be replaced by the new set of configuration files which are uploaded by the research administrator, the general administrator in the future.

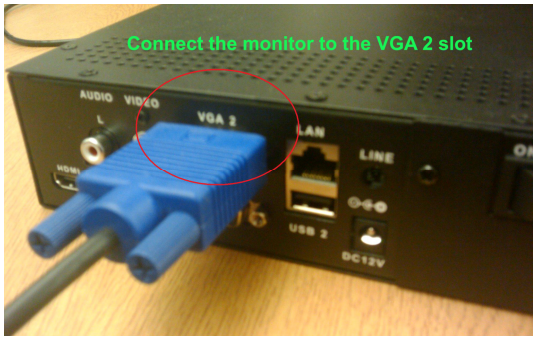


Figure 3-10. Connect monitor to VGA slot of maxIPAD

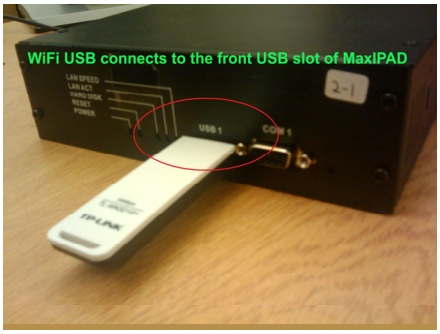


Figure 3-11. Wi-Fi USB dongle connects USB slot of maxIPAD

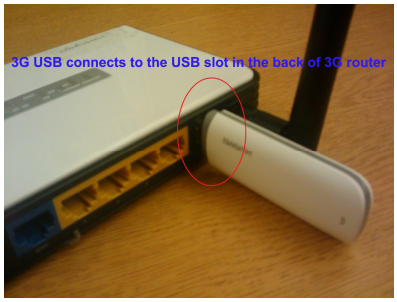


Figure 3-12. 3G USB modem connects to the 3G router

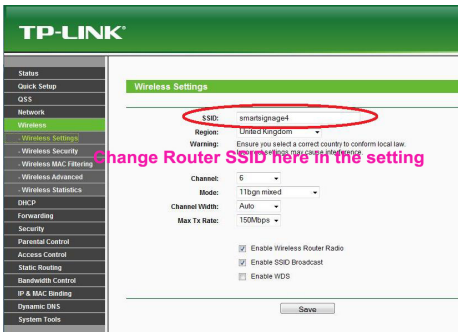


Figure 3-13. 3G router SSID setting

In case that multi-signage deployment is required, multiple maxIPADs can be configured to connect to one single router (Figure 3-14), and each signage can display its own playlist and allow the phone subscriber to synchronize their phone to the signage when he points at one of the signage holding the smartphone. Each maxIPAD can retrieve its new configuration files from its assigned FTP server in the cloud.

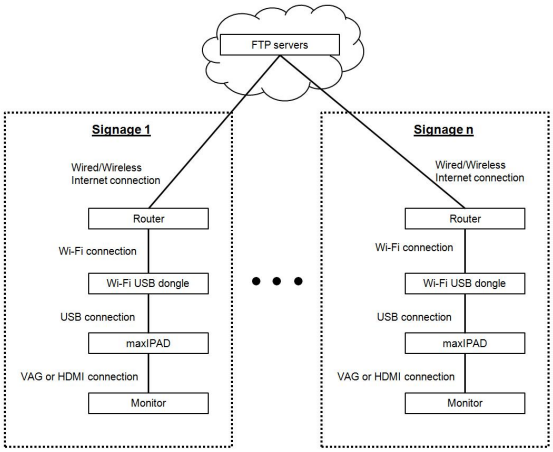


Figure 3-14. Multiple signage setup

Chapter 4
Smart Signage Phone Application

This chapter is focusing exclusively on the Smart Signage Phone Application. This phone application takes phone subscriber's gesture as input in order to acquire the images from the signage. This chapter is broken into three subsections. Section 4.1 introduces the digital information sent from the signage that can be acquired by the smartphone. Section 4.2 gives instruction of how to perform the gesture to interact with the smartphone. Suction 4.3 shows the phone application user interface and introduces its basic functions.

4.1 Phone Application Background

Before the phone subscriber is able to interact with the signage using his phone, some digitalized information needs to be downloaded into the smartphone. There digitalized information is called draggable. As it was previously stated in Secton 3.2.1., these draggables are generated by the administrator using the Web Tool. There are two kinds of draggale namely the thumbnail draggable and the text draggable. The thumbnail draggable is the image file which represents the image display in the signage. The text draggable is a XML file which contains information about this image. For the smartphone to work properly with the signage, the smartphone has to download these draggables in the temporary memory of the smartphone.

As Chapter 3 has mentioned previously, each draggable is assigned with an URI, X, and Y in its filename. URI is the unique identification number assigned to the image. X and Y are corresponding to azimuth value and pitch value of particular signage which the draggable belongs to. X value is the azimuth angle of the horizontal position of the signage relative to the phone subscriber's position on the floor surface. Y is the pitch angle of vertical position of the signage relative to the phone subscriber's position on the floor surface. Currently, the Y value is not used by the phone application. The latest phone application is designed to work with multiple signagles are horizontally adjacent to each other where only the X value is applicable. Under the particular signage's signal coverage, if the phone subscriber is facing to this signage and the azimuth angle of the horizontal position of this signage relative to the phone subscriber's position on the floor is equal to the X value, the phone subscriber's smartphone would interact with this signage.

4.2 Gesture as Input

The Smart Signage Phone Application is designed to enable the phone subscriber to interact with the signage by performing gestures with his smartphone. After the phone subscriber performed a gesture, the sensor inside the smartphone catches the gesture movement and translates the movement into value. Then, the Smart Signage Phone Application takes this value as an input to perform task accordingly. This section introduces the two features of the Smart Signage Phone Application which require the phone subscriber to perform gesture in order to carry out the tasks.

Figure 4-1. Phone subscriber drags towards the signage where white arrow is the signage location

The first feature of this phone application is to allow the phone subscriber to acquire the digital information by pointing to the signage and then performing the dragging gesture (Figure 4-1) with his smartphone. As soon as the phone application is activated and the phone subscriber is approaching to the signage, the phone should verify whether the network which the signage is belonging has a preferred SSID. After the network is verified as a valid one, the phone attempts to establish Wi-Fi connection to the network, and then it starts downloading the draggable in the form of datagram. After the smartphone has collected all of datagrams for the draggable of the image, the smartphone will generate the thumbnail draggable and text draggable using these datagrams. Then, these two draggables are stored in the temporary memory inside the smartphone. At this moment, the smartphone should notify the phone subscriber he can perform dragging gesture at any time.

When the phone subscriber is ready to “drag” the image, he points to the signage holding the smartphone and then performs the dragging movement holding the smartphone. After the dragging movement is accomplished, the phone application should display the thumbnail draggable which is synchronizing to the image that the phone subscriber just dragged from the signage. When the thumbnail draggable is displayed in the phone screen, the phone subscriber to confirm and then store

the image in the collection or to discard this dragged image. After the phone subscriber has confirmed to acquire this image after the drag, the application stores a copy of the thumbnail draggable in a collection folder inside the smartphone's the SD card. This feature has already been achieved in the current stage of the project.

The secondary feature is a proposed feature which allows the phone subscriber to share draggable by swinging the sender smartphone (Figure 4-2) toward another receiver smartphone. After the swinging movement is performed, temporary wireless connection should be established between the sender smartphone and the receiver smartphone, and then the draggable the sender wants to share would be transmit to the receiver smartphone. After the receiver has received the draggable in his smartphone, the temporary wireless connection is dropped. Then, the draggable receiver can either accept or discard the incoming draggable. At this stage of the project, this swing-to-share is not implemented in the current phone application.

Figure 4-2. As shown from left to right, the phone subscriber can swing the smartphone to share dragable

4.3 Application User Interface

This section is focusing on the phone application user interface and its functionalities, and it is broken into several subsections to explain the each functionality in the phone application user interface and application states. Subsection 4.3.1 describes the three initialization states before the application is ready for phone subscriber to use. Subsection 4.3.2 presents the pseudo code to explain how the smartphone is connected to the network and how the draggale is downloaded. Subsection 4.3.3 introduces the main functions in the main menu interface. Subsection 4.3.4 describes the different methods the application can interact with the phone subscriber when the application is ready to use. Sucbsection 4.3.4 shows different application modes to display the thumbnail draggable once it is downloaded to the smartphone and synchronizing to image displayed in the signage. Subsection 4.3.5

describes the additional functionality of the draggable. Subsection 4.3.6 describes the setting interface of the application. The section 3.3.7 describes the application's preference function which allows the phone subscriber to download only preferred category of draggable to the phone.

4.3.1 Application Initialization Sates

When the phone application is provoked by the phone subscriber, the phone application needs to go through a series of initialization states before the phone subscriber can interact with the signage using the smartphone. There are three initialization states, namely Idle State (the image on the top left in Figure 4-3), Connecting State (the image in the right side in Figure 4-3), and Ready State (the image on the bottom left in Figure 4-3). In Idle State and Connecting State, the smartphone scans for available wireless network, evaluates the scanned network, and then tries to establish connection to the valid network. When the initialization is in the Ready State, the phone subscriber is able to interact with the smartphone. Figure 4-3 shows how one state can shift to another state under given condition.

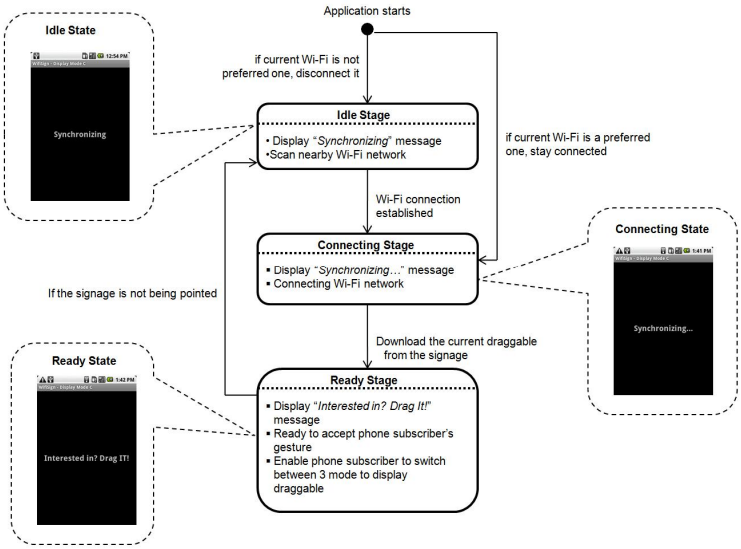


Figure 4-3. Application initiation: Idle State, Connecting State, and Ready State

At the phone subscriber points a signage using his smartphone and starts the phone application, the phone application usually begins in the Idle State. When the phone application is in the Idle State, it displays a message saying "Synchornizing" (the image on the top left in Figure 4-3) which indicates that the smartphone is not connecting to any network. Then, the phone application makes the

smartphone to scan nearby networks for signage signal. When the smartphone detects signage signal from a network, the phone application will check if SSID of this network is equal to one SSID in a SSID preference list. If the network is verified to hold a preferred SSID, the smartphone will proceed to establish Wi-Fi connection with this network, and, then, the application will enter the Connection State (the image in the right side in Figure 4-3).

When the smartphone is connecting to the network, the phone application is in the Connecting State. While the phone application is in the Connecting State, it displays a message saying "Synchoronizing…"(the image in the right side in Figure 4-3) to indicate that Wi-Fi connection is established and the phone subscriber should continue to point the signage with his smartphone. As the phone subscriber continues to point the signage with the smartphone, the draggable is downloaded to the smartphone. Only the draggable, representing the image currently being displayed in the signage, is downloaded during the time the image being displayed in the signage. Now, the phone application is in the Ready Mode, and the smartphone will continue to download other draggables as the signage displays the other images.

The smartphone is ready to take gesture as input in the Ready Mode. While the phone application is in the Ready Mode, it displays "Interested? Drag it" message to tell the phone subscriber that he can interact with the signage by performing gesture now. However, if the phone subscriber moves out of the router's coverage or starts pointing to another direction where there is no signage, the application will go back to the Idle State. When the phone subscriber tilts the smartphone back to the direction where the signage is, the application goes back to the Ready State and displays "Interested in? Drag it" message. At this moment, if the phone subscriber performs the dragging gesture while pointing the signage with the smartphone, the phone application will display the thumbnail draggable which synchronize to the current image displayed in the signage.

In case of multi-signage setup where there is more than one signage connecting to one router, the smartphone needs to go through the three initialization states with each signage. For example, if there are two signages in the location where the phone subscriber is, the phone subscriber can point to one signage, and the smartphone will display its current state of the signage (Top image in Figure 4-4). If the phone subscriber points to another signage, the smartphone will display its current state of the second signage (Bottom image in Figure 3-4).

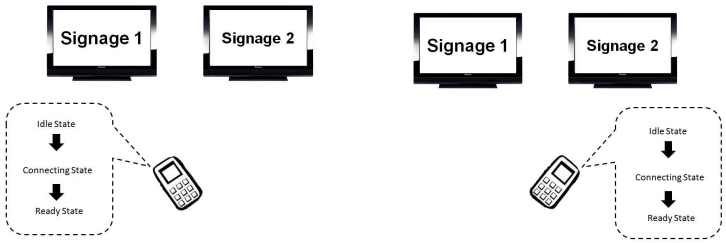


Figure 4-4. Smartphone displays the current state of the signages in the case of multi-signage

4.3.2 Pseudo Code for Network Connection and Draggable Acquiring

The pseudo code in Figure 4-5 and Figure 4-6 play important rule to enable the phone application to shift from one initialization state to another and to receive datagrams from the signage. The pseudo code statement from line 1 to line 19 in Figure 4-5 is verify the current Wi-Fi connection. If SSID of the current network is not equal to those in the SSID preference list from the setting.properties file, this statement will disconnect the smartphone from the current network by disabling Wi-Fi function. In case that SSID of the current Wi-Fi network is in the preferred SSID list, the phone application allows the smartphone to continue connecting to the current Wi-Fi network and proceeds to the pseudo code in Figure 4-6. In the case that the current network is disconnected by the statement from line 1 to line 19 in Figure 4-5, the statement from line 21 to line 33 will attempt to re-establish the Wi-Fi connection. This is done by scanning for the nearby networks, and then these scan result is verified to see if SSID's of the nearby networks match to these in the SSID preference list. The smartphone establishes Wi-Fi connection to the network which holds the preferred SSID. As the Wi-Fi connection is established, the phone is entering the Connecting State. Thus, the pseudo code form line 1 to line 19 in Figure 4-5 is responsible for the phone application to be in the Idle Mode, and the pseudo code form line 21 to line 33 in Figure 4-5 is responsible for the phone application to be in the Connecting Mode.

```
1 EXTRACT ssid list from setting.properties file
2 SET currentSSID = ssid of current network
3 DECLARE ssids[] <- ssid.split(",")
4 SET counter to 0
5
6 IF (Wi-Fi is enable) then
7    IF (no network connected) then
8       DO disable DISABLE Wi-Fi (1)
9    ELSE
10      FOR each element in ssids[]
11         IF  (currentSSID is NOT EQUAL to current element in ssids[])
12     INCREMENT counter by 1
13         END IF
14      END FOR
15      IF (counter == ssids[].length) then
16         DO disable Wi-Fi
17      END IF
18   END IF
19 END IF
20
21 IF (Wi-Fi is disabled) then
22   Enable Wi-Fi
23   SET scanResult[] <- Do ScanNetwork
24      WHILE_OUTTER (int x = 0; x < scanResult.length; x++)
25        WHILE_INNER (int y = 0; y < ssid.length; y++)
26                  IF (scanRuslt[x].SSID == ssid[y].SSID)
27              Enable network with networked with ssid[y].SSID
28          DO break WHILE_OUTER
29               ENDIF
30        END WHILE_INNER
31         END WHILE_OUTTER
32      END IF
33 END IF
```

Figure 4-5. Pseudo code for establishing preferred Wi-Fi connection

In the Connecting State, the smartphone will jin the multicast group in order to receive datagrams from the signage. The pseudo code statement from line 1 to line 3 in Figure 4-b illustrates how multicast socket *ms* is created and is set to join the multicast group 239.0.211.0. The pseudo code statement from line 6 to the last line is responsible to handle the datagrams from the signage. There are two types of datagram being handled while in the while loop. The first type of datagram is handled by the statement from line 10 to line 14, and this datagram contains information of which signage the phone is currently pointing to and what image the signage is displaying. The second type of datagram is handled by the statement from line 16 to line 37. The second type of datagram contains the same information as the one in the first type of datagram, and, in addition, it also includes parts of the thumbnail draggale or the text draggable. In the signage end, the thumbnail draggable and the information draggable, which belong to the same image, are combined together, divided into many datagrams, and then sent to the smartphones through multicasting. Since these datagrams are broadcasted using UDP, and the datagrams would not arrive to the recipient in the right order. Thus, the pseudo code (line 29 in Figure 4-6) has to arrange the order of the datagrams while it is collecting these datagrams. When all of the datagrams, which belong to one image, are collected completely, the thumbnail draggable and the text draggable are generated and stored under /sdcard/img/ folder.

```
DECLARE hashMap (string as key is a string; fileBuffer as value)
SET socket ms and bind it to port '5353'
SET ms to JOIN multicastGroup 239.0.211.0
INITIAL datagram
SET buffer
WHILE (true)
   SET DatagramPacket dp <- new DatagramPacket(buffer, buffer.length)
   DO datagram <- ms.receive(dp)
   IF (dp.length() EQUAL 10) then
      EXTRACT showingURI from datagram
      EXTRACT xAxis from datagram
      EXTRACT yAxis from datagram
      SET pointedSignage with xAxis and yAxis
      DO pointedSignage.UPDATE( showingURI)
   ELSE
      EXTRACT broadcastingURI from datagram
      EXTRACT totalNumberOfDatagram from datagram
      EXTRACT datagramNumber from datagram
      EXTRACT showingURI from datagram
      EXTRACT xAxis from datagram
      EXTRACT yAxis from datagram
      SET pointedSignage with xAxis and yAxis
      DO pointedSignage.UPDATE( showingURI)
      IF (broadcastingURI.JPG does not exist in "/sdcard/img/" folder) then
         IF (hashMap DOES NOT contain a key EQUAL boardcstingURI)) then
            DO associate the EMPTY buffer with boardcstingURI key in this hashMap
         END IF
         IF ((the buffer associated to boardcstingURI key) DOES NOT have datagram) then
            STORE datagram in the buffer associated to boardcstingURI key in hashMap
         END IF
         IF (total number of datagrams in the buffer associates to boardcstingURI key EQUALS to totalNumberOfDatagram) then
            GENERATE /sdcard/img/broadcastingURI.XML file using the datagrames stored in the fileBuffer associate to boardcastingURI key
            GENERATE /sdcard/img/broadcastingURI.JPG file using the datagrames stored in the fileBuffer associate to boardcastingURI key
            REMOVE boardcastURI key and its value from hashMap
         END IF
      END IF
   END IF
END WHILE
```

Figure 4-6. Pseudo code for receiving datagram from signage

4.3.3 Main Menu User Interface

After the phone application is ready for the interaction between the phone subscriber and the signage using the smartphone, the phone subscriber can press the Menu button to trigger the main menu interface (the portion in square in Figure 4-7). This main menu interface is consisting of five buttons namely *Picture/Text*, *Collection*, *Preference*, *Display Mode*, and *Setting*. The *Picture/Text* and *Display Mode* buttons enables the application to switch between three draggable displaying modes. The *Collection* button enables the application to display a list of draggables which are already being dragged by the phone subscriber. The *Setting* button allows the phone subscriber to re-configure the application setting. The *Preference* button allows the phone subscriber to acquire the preferable draggables belong to specific categories preferred by the phone subscriber. The rest subsections describe the other functionalities in the phone application's main menu interface.

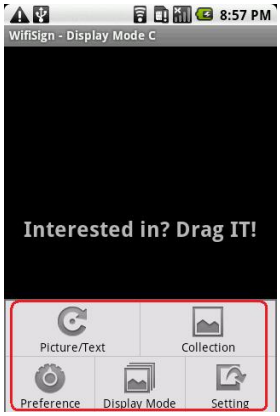


Figure 4-7. Application main menu user interface

4.3.4 Application Modes

After the application is in Ready State of the application initialization, the phone subscriber can interact with the signage using the smartphone by performing gesture, and he also can choose three different application modes to display draggable. These three draggable displaying mode are namely Text Mode (Figure 4-9), Picture Mode (Figure 4-10), and Display Mode (Figure 4-11). The Text Mode is the default mode displaying a message to indicate the smartphone is ready to take gesture as input. Picture Mode displays the thumbnail draggable which is synchronizing to the current image displayed in the signage. The Display Mode displays a loop of thumbnail draggables from the pointed signage and allows the phone subscriber to browse through the looping list. The phone subscriber is able to switch between the three mode in his will (Figure 4-8), and these modes are different in their way to displaying the thumbnail draggable in the smartphone.

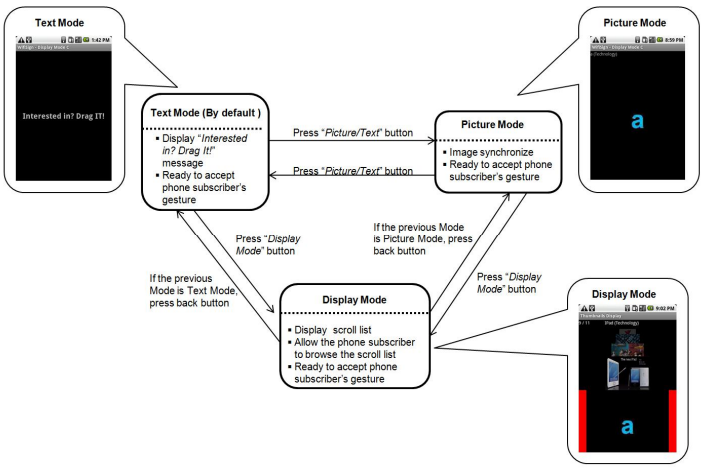


Figure 4-8. Three application modes to display draggable

As soon as the phone application is ready to take the phone subscriber's gesture as input, the phone application enters the Text Mode (the image on the left side in Figure 4-9) by default. In the Text Mode, the phone application is showing a message saying "Interested in? Drag IT" in the phone screen. As the phone subscriber is pointing the signage and seeing the desired image being displayed in the signage, he can perform the drag gesture holding the smartphone. After the drag gesture is performed to the current image being displayed in the signage, the phone displays the thumbnail draggable followed by a Confirm button and a Cancel button (the image on the right side in Figure 4-9). Then, the phone subscriber can either press the Confirm button to store the dragged thumbnail draggable to the collection or to press the Cancel button to withdraw the action. The phone subscriber can switch to Picture Mode by pressing Picture/Text button in the main menu, or he can switch to Display Mode by pressing Display Mode button in the main menu.

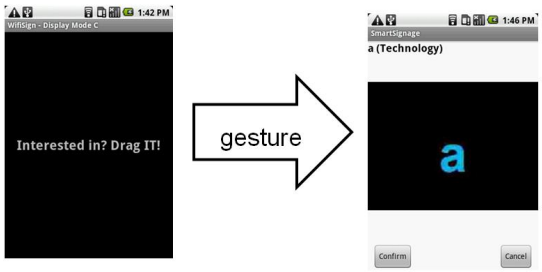


Figure 4-9. Text Mode before (left) and after (right) the drag gesture performed

The Picture Mode (Figure 4-10) is the mode which displays the thumbnail draggable synchronizing to the image display by the signage. To access the Picture Mode from the Text Mode, the phone subscriber can click the Picture/Text button in the Main Menu interface (Figure 4-7). When the main menu appears, the phone subscriber can press "Picture/Text" to switch from Text Mode to Picture Mode. In the Picture Mode, the thumbnail draggable being displayed in the phone screen is synchronizing to the image being displayed by the signage (the image on the left side in Figure 4-10). In the Picture Mode, the phone subscriber can view either the phone screen or the signage to choose the desire image to display, because the thumbnail draggable in the phone screen should synchronize to the image in the signage. Now, the phone subscriber can perform the drag gesture towards the signage when he sees the desire image he would like to acquire. After the gesture is performed toward the signage, the application gives the phone subscriber the options to either to acquire the draggable or to cancel the action (the image on the right side in Figure 4-10). Then the phone subscriber can either press the Confirm button to store the dragged thumbnail draggable to the collection or to press the Cancel button to withdraw the action. The phone subscriber can switch back to the Text Mode by pressing Picture/Text button in the main menu, or he can switch to Display Mode by pressing Display Mode button in the main menu.

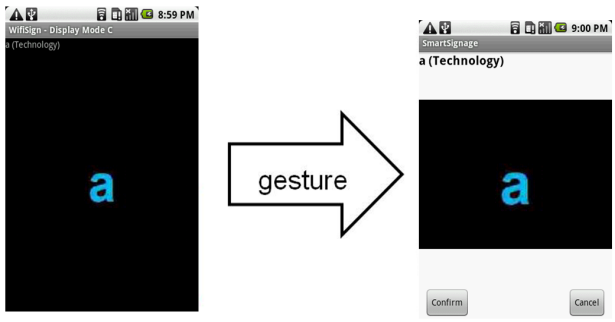


Figure 4-10. Picture Mode before (left) and after (right) the gesture performed

The Display Mode (Figure 4-11) is similar to the Picture Mode, but it shows a scrolling list of thumbnail draggables instead of one current thumbnail draggable synchronizing to the image being displayed in the signage. To access the Display Mode, the phone subscriber can click the Display Mode button in the main menu interface (Figure 4-7). In the Display Mode, the phone subscriber will see a scrolling list of thumbnail draggables belongs the signage (the image on the left side in Figure 4-11), and the phone subscriber can scroll up and down to browse through the thumbnail draggable list. The thumbnail draggable in red box in the button of the list in the user interface (the image on the

left side in Figure 4-11) indicates this thumbnail draggable has not being dragged into the collection folder by the phone subscriber. After the phone subscriber has performed the gesture when he sees desire thumbnail draggale in the scrolling list, the application gives the phone subscriber the options to either to acquire the draggable or to cancel the action (the image on the right side in Figure 4-11). Then the phone subscriber can either press the Confirm button to store the dragged thumbnail draggable into the collection folder or to press the Cancel button to withdraw the action. If the phone subscriber has confirmed the action, this thumbnail draggable will be shown in the Collection (please refer to Section 4.3.5). In addition, this thumbnail draggable in the list will appeared to be in a green box (figure 4-12), and this also indicates that this thumbnail draggable has been confirmed to be acquired in the Collection.

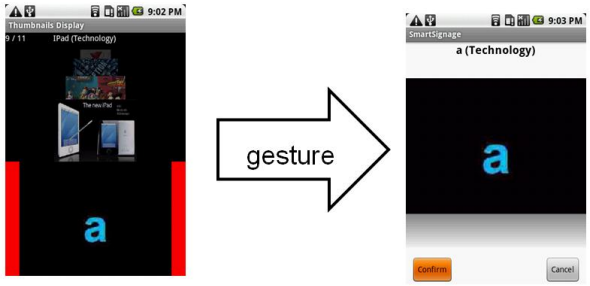


Figure 4-11. Display Mode before (left) and after (right) the gesture performed

Figure 4-12. Green color side bar indicates draggable has been acquired

4.3.5 Social Media Functions in the Collection

The Collection list can be accessed by pressing the Collection button in the main menu (Figure 4-7). The thumbnail draggables in this Collection list (Figure 4-13) are these being dragged by the phone subscriber. Inside this Collection list (Figure 4-13), the phone subscriber can explore detail

information of each draggable by pressing the thumbnail draggable. After one draggable is pressed, the detail information of the draggable is presented (Figure 4-14). This detail information is consisting of four social media functions namely *Go to Website*, *Call*, *Send SMS*, and *Map*. These social media functions allow the phone subscriber to explore more information related to this dragglabe.

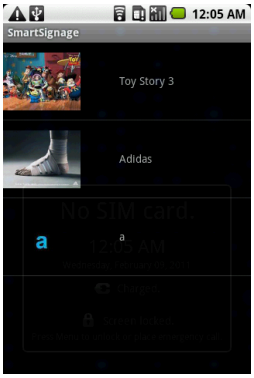


Figure 4-13. Collection list with acquired three draggables

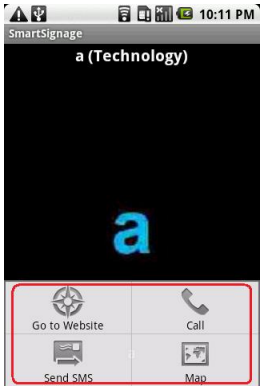


Figure 4-14. Social media function

To access the social media function of these thumbnail draggables inside the Collection list, the phone subscriber can press the smartphone's Menu button to activate social media function menu (in the red square in Figure 4-14). The social media function menu is consisting of a *Go to Website* button, *Call* button, *Send SMS* button, *and Map* button. By pressing the *Go to Website* button, it will provoke an Android Internet browsing application with a given URL which will lead the phone subscriber to a webpage containing draggable-related information. By pressing the *Call* button, it will provoke the dialer application with a given telephone number, and then the phone subscriber will be

able to make a phone call with the given telephone number. By pressing the *Send SMS* button, it will provoke the Android SMS application with a given phone number to enable the phone subscriber to send a SMS message to the given phone number. By pressing the *Map* button, it will provoke the Google Map with a given coordinate to reveals a geographical location. These values for social media functions are stored in the XML format in the text draggable file which is downloaded to phone when the phone is in the Connecting State in the application initialization. While in the Connecting State, the phone collects the datagrams sent out by the signage, and then the phone application generates the text draggable by putting the datagarams together. The text draggable is an XML file with the following format:

```
<?xml version="1.0" encoding="UTF-8"?>
<Videos>
   <Video name="a">
      <Remarks>This is a</Remarks>
      <URL>http://www.cl.ca.ac.uk</URL>
      <TEL>9057923174</TEL>
      <SMS>4167923174</SMS>
      <GPS>geo: 190,130</GPS>
   </Video>
</Videos>
```

The <Remarks>tag holds a short remark about the draggable. The <URL>tag holds the URL which is needed when the phone subscriber provokes the web browser by pressing the “Go to Website” button in the Social Media Function menu (Figure 4-14). The <TEL> tag holds a set of telephone number which is needed when the phone subscriber provokes the dialer application by pressing the Call button in the Social Media Function menu. The <SMS> tag holds a telephone number which is required by the Android SMS application when the phone subscriber provokes the SMS application by pressing the Send SMS button in the Social Media Function menu. The <GPS> tag holds a set of X and Y coordinate which is needed when the phone subscriber provokes this application by pressing the Map button in the Social Media Function menu. This XML file is generated by the Web Tool by the research administrator.

4.3.6 Application Setting

The phone subscriber can access and configure the setting (Figure 4-15) of the phone application by pressing the Setting button in the main menu (Figure 4-7). The application setting allows the phone subscriber to modify SSID preference list, to view the currently connected SSID, to turn on/off

Bluetooth and GPS functions, and to choose to receive draggables from project or signage. The SSID Preference text field holds a SSID preference list, and the phone application accepts datagrams from signages only if the connected network's SSID is equal to one SSID in the SSID preference list. The Bluetooth checkbox enables the Bluetooth function of the phone. The GPS checkbox enables the GPS function of the smartphone. The Projector Enabled checkbox enables the phone to receive information from the projector instead of form a maxIPAD. A projector is a desktop application that simulates the signage operations. The projector is mainly applied by the research administrators for application developing purpose. The datagram sent out by the projector is in different format from the one sent out by the signage. Thus, the Projector Enabled checkbox enables the phone application to recognize the datagrams sent by the projector and handle them differently.

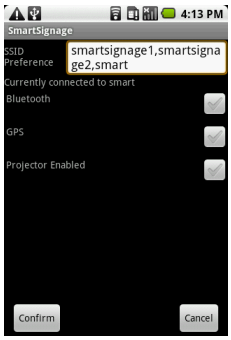


Figure 4-15. Setting of Smart Signage phone application

The configuration in setting interface is stored in a text file named setting.propties inside the SD card once the Confirm button (Figure 4-13) is pressed. The following is the content of the setting.properties file:

```
#Sun Feb 06 13:38:38 Asia/Taipei 2011
ssid=smartsignage1,smartsignage2,smartsignage3
gps=off
bluetooth=off
projector=off
```

The setting.properties file contains four variables namely ssid, gps, bluetooth, and projector. The ssid variable holds a list of SSID of valid signage. When the phone application is active, this SSID list is referred to verify if the current network holds a preferred SSID. The gps variable indicates whether the phone's GPS functionality is on or off. The bluetooth variable indicates whether the phone's Bluetooth functionality is on or off. The projector variable indicates whether the current datagram sender is a projector or a signage. Before the phone application starts to probe for incoming signal, it

will check this projector variable to decide whether if it will detect for signal coming from a projector or from a maxIPAD. This setting.properties file is accessed by the phone application when the application is just started. At the start of the phone application, the application refers to the variables in the setting.properties file to configure the setting of the smartphone. If the setting.properties file does not exist in the SD card, the application can still configure the phone with its default setting values.

4.3.7 Preference User Interface

The draggables, which is sent out in the form of datagram by the signage, can be classified by different categories. The phone subscriber can set up category preference and enable his smartphone to download the draggables belong to the preferred categories. This can be achieved by the applying the application's Preference (Figure 4-16). The Preference can be provoked by pressing the Preference button in the Main Menu (Figure 4-7). So far, there are seven categories which the phone subscriber can choose from. These categories are namely Movie, Sports, Games, Clothes, Food, and Finance, and Technology.

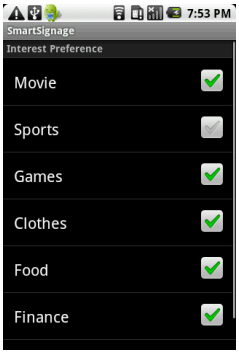


Figure 4-16. Preference user interface

While the smartphone is synchronizing to the image displayed by the signage, the application will download the draggables with categories being checked in the Preference (Figure 4-16). When the phone application is in the Connecting State of application initialization, the application checks the Preference configuration and be sure to download the draggables belong to the checked categories in the Preference. Figure 4-16 shows the checkbox of the Sports category has been left empty. This results the phone to download draggables that are not in the Sports category. As a result, the application in Text Mode (Figure 4-9) is displaying a message staying that "To drag, please enable

Sports in preference" (Figure 4-17) when the signage is displaying a draggable belongs to Sports category. If the phone subscriber has checked the checkbox of the Sports category, the smartphone will accept the draggable in the Sports category.

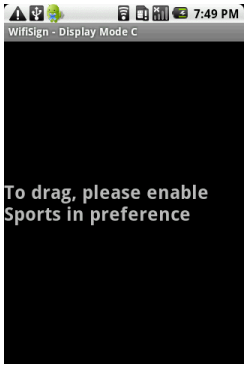


Figure 4-17. Result of draggable's category is disabled

4.4 Multiple Signage Arrangement Development

In the current status of the project, the phone application is only able to interact with multiple signages that are horizontally adjacent to each other (Figure 4-18), but it is not capable to recognize the signage position when one signage is on top of another. Thus, the next stage is to modify the phone application, so it can work with the signages in vertical order (Figure 4-19) instead of the signages in horizontal order.

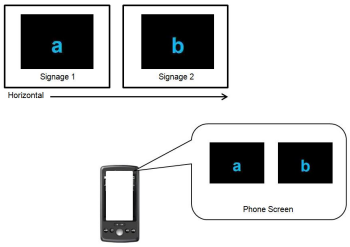


Figure 4-18. Signages in horizontal arrangement

In the previous detail which talking URI_X_Y file name convention, it was mentioned that the current phone application utilizes only the X value while the Y value is reserved and not used, because the application needs only the X value to recognize signages in horizontal order (Figure 4-18). In order to work with signage in vertical order (Figure 4-19), the modified phone application will

need to utilize the Y value in order to recognize the signages in vertical arraignment. After it is confirmed that the new phone application is able is able to work with signages in vertical order without any faults, the whole project can move to the stage to enable the phone application to works with multiple signage in horizontal and vertical combination arrangement (Figure 4-20).

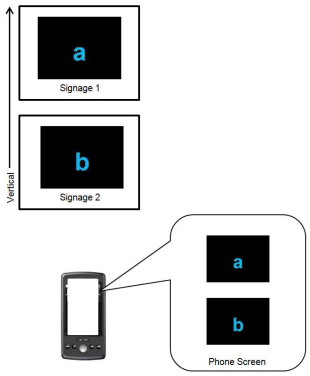


Figure 4-19. Signage in vertical arrangement

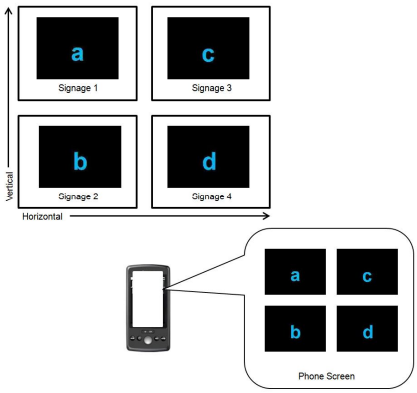


Figure 4-20. Combination of horizontal and vertical arrangement

Chapter 5
Experiments

Chapter 5 describes the experiments that have been conducted in single signage and multiple signage scenarios. All of the experiments have been done in the William Gates Building in the University of Cambridge. This chapter is divided into three sections; Section 5.1 deals with experiment in the single signage scenario, Section 5.2 discusses multiple signage deployments in the spacious hallway in William Gates building ground floor and the problems found during the deployment, and Section 5.3 remarks some finding during the experiments.

5.1 Single Signage Experiment and Result

The single signage experiment is broken down into two parts. In the first part, the performance of Wi-Fi Internet access and 3G Internet access in the single signage deployment will be discussed. The second part of the experiment is focusing on how fast the phone application can enable smartphone to switch from an un-preferred network to preferred network.

Even though Chapter 3 has introduced three Internet access setup, only two wireless Internet access methods are considered to be applied in the experiment. These two wireless Internet access methods are Wi-Fi and 3G. The wired Internet access method is not considered in this experiment, because this method creates constraints to the administrator by requiring the signage components to be near to the Ethernet cable in order to access Internet. Thus, it gives the administrator less flexibility on signage arrangement during the setup.

While comparing the signage performance between 3G Internet access and Wi-Fi Internet access, it is found that maxIPAD is able to download data from ftp server smoothly with 3G Internet access. Internet stability is a quite important factor when there is data transmission from ftp server to maxIPAD. The maxIPAD is set up to retrieve information from ftp server every ten minutes periodically. Unfortunately, the signage setup with Wi-Fi Internet access is unable to have maxIPAD to receive the update data from the ftp server on time, and the delay could be more than ten minutes or longer. The reason behind this is because the Wi-Fi Internet bandwidth is shared by other workstations within the entire building, and the delay is especially obvious during the office hours. Contrary to Wi-Fi, 3G Inter access allows the signage to retrieve the update on time, because 3G

Internet bandwidth is exclusively for the signage usage. Since the delay problem can be solved by replacing Wi-Fi Internet access with 3G, it is decided that the 3G should be considered as the primary Internet access choice in the future signage setup.

As soon as the phone application is on, it is ideal to have the smartphone to switch to the preferred Wi-Fi network from foreign network as soon as possible, and, therefore, the time for the phone application to switch from un-preferred Wi-Fi network to preferred Wi-Fi network is another factor which can affect the application performance. The timing experiment procedure is done with following steps:

1. Before starting the phone application, connect to a un-preferred Wi-Fi network A
2. Start the phone application and start timing as soon as the phone application starts
3. Go to phone application's setting to check the status of the currently connected Wi-Fi network
4. As soon as the currently connected Wi-Fi network to a network B in the preferred SSID list, stop timing

The Table 5-1 shows require for the phone application to switch from un-preferred Wi-Fi network to a preferred Wi-Fi network:

Table 5-1. Experiment result

	Duration (second)
1	9
2	10
3	10
4	9
5	10
6	10
7	11
8	10
9	10
10	9

The above procedure has been iterated ten times with the phone application, and this shows that the duration for the application to switch to the preferred network is 9.8 seconds in the average. For

average phone subscriber, nine minute waiting time should be relatively short because some Android-based applications can take more than nine minutes to load before the application is ready for user input.

5.2 Multiple Signage Experiment and Result

This section describes the multiple signage experiment with 3G Internet access in a greater test ground, and the purpose of the experiment is to test the signage signal coverage. After the success of the multiple signage setup with 3G Internet access in the computer laboratory in William Gates Building (WGB), it was decided that the same deployment scheme should be carried out in a spacious area such as William Gates Building Ground Floor (Figure 5-1) in order to observe how well the smartphone can detect the signal from the signages. The two signages are set up to be close to the wall and facing towards the hallway (as located in Position A and Position B in Figure 5-1). In this scheme, the two signages are sharing one router for data transmission, and the router is positioned behind Signage A by convenience. The ground floor was being divided into ten areas (gray portion in Figure 5-2) for the purpose of this experiment, and the research administrator stood in the center in each area and hold the phone pointing to the points of interest of the two siganges (Figure 5-3) to see if the smartphone is able to receive signal from each signage.

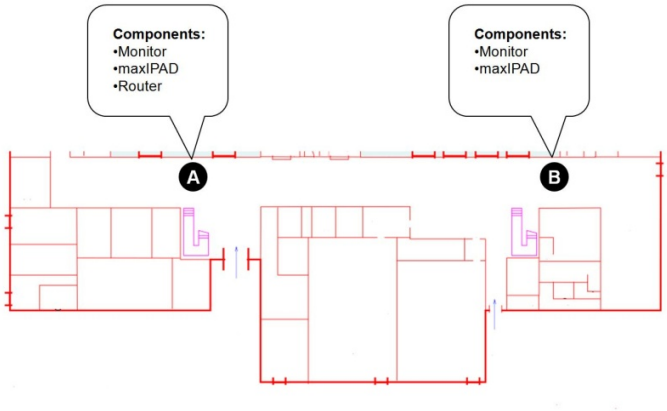


Figure 5-1. Multiple signage deployment with 3G Internet access in WGB

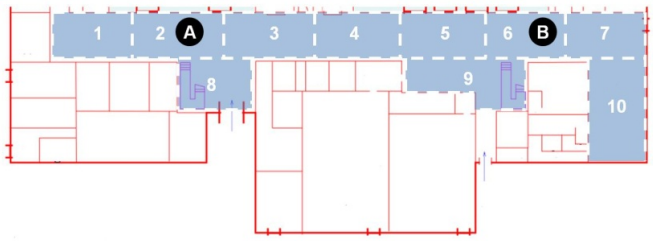


Figure 5-2. Floor plan is divided into 10 areas

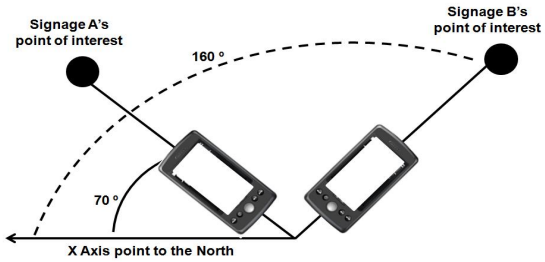
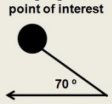
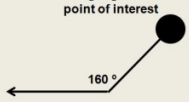


Figure 5-3. Pointing the point of interest of the signages with the smartphone

There were problems revealed during and after the experiment. The first problem encountered was that it took a long time for Signage B to receive update from ftp server after Signage B was switched on. The maxIPAD is set to retrieve information from ftp server ten minutes, and it usually took the maxIPAD more than ten minute to finishing download the complete playlist from the ftp server. When this was happening, Signage B would not display the complete playlist; some of the images in the playlist were skipped in the playlist. The second problem is that, even if Signage B was able to download the complete playlist from FTP server, the smartphone was still unable to receive the complete thumbnail draggable lists of Signage B. As the experiment result in Table 5-2 has shown, the smartphone displays thumbnail images from Signage A when the smartphone is pointing to There were cases when the smartphone was only able to detect the present of Signage A only. This result shows that there was a data transmission between the router and Signage B.

Table 5-2. Multiple signage setup test result

Area	Signage A's point of interest 	Signage B's point of interest 
1	Show image from A	No image
2	Show image from A	No image
3	Show image from A	No image
4	Show image from A	No image
5	Show image from A	No image
6	Show image from A	No image
7	Show image from A	No image
8	Show image from A	No image
9	Show image from A	No image
10	Show image from A	No image

The proposed solution to solve the above mentioned problems is to move the router to the centre point between the two signages. The router was moved in the centre of area 4 (Figure 5-4), which also means that there is equal distance from Signage A to the router is equal and from Signage B to the router. After the router was moved to the new position, signage B is able to receive update from ftp server within reasonable time, and the smartphone is able to display the image from the signage when the smartphone is hold to point the orientations of the signages as shown in Table 5-3. One additional suggestion for the multiple signage is that it is better to move the signage to the extreme corner of the deployment location. In Figure 5-4, the phone subscriber is intuitively expecting the smarphone to display image from Signage A when phone subscriber is pointing to Signage A holding his smartphone in the centre of Area 1, but the phone application is designed to display images from the signage according to azimuth of the signage. Therefore, the smartphone will display image from Signage B, but not one from Signage A. This issue can be remedied by moving the signage to the extreme corner of the room. For example, Signage A can move in the top left corner of Area 1 and Signage B can move to top right corner of Area 7. In this way, there is lower chance when the phone subscriber will run into the confusion of pointing at Signage A but getting image from Signage B, and vice versa.

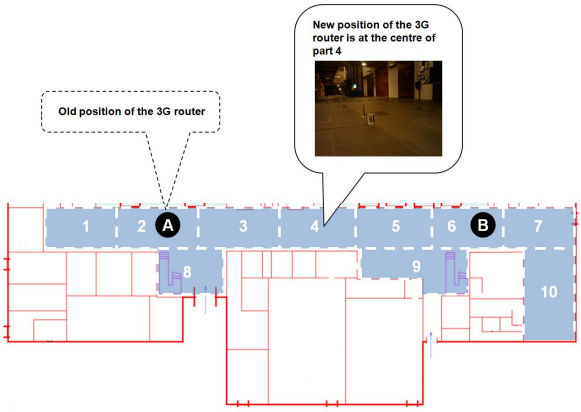
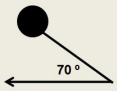
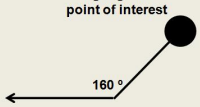


Figure 5-4. 3G router repositioning to Area 4

Table 5-3. Multiple signage setup test result after the router is relocated

Area	Signage A's point of interest 	Signage B's point of interest 
1	Show image from A	Show image from B
2	Show image from A	Show image from B
3	Show image from A	Show image from B
4	Show image from A	Show image from B
5	Show image from A	Show image from B
6	Show image from A	Show image from B
7	Show image from A	Show image from B
8	Show image from A	Show image from B
9	Show image from A	Show image from B
10	Show image from A	Show image from B

5.3 Additional Remark

The phone application has been tested exclusively on G1 Android phone, and it is found that the current phone application can present images with a size of 200 by 150 pixels better resolution on the phone screen. File size is another factor affecting application performance. An image with file sizes below 5 kilobytes would show poorer resolution on the G1 screen, but an image with file sizes greater than 9 kb kilobytes results in noticeable increased image downloading time.

Chapter 6
Conclusion

Traditionally, people rely on memory and note taking to keep track of information they see in the advertisement, but information gets lost easily by do so. Thus, this thesis introduced Smart Signage framework, which enables the phone subscriber to acquire information with his smartphone form computerized signage using gesture-based application.

Nowadays, the phone's purpose is not solely for one-to-one verbal conversation any more. The earliest works on gesture-based phone application was built to perform gesture to operate the application within the phone, and these works have shown that the phone was able to recognize the phone subscriber's gesture with very high accuracy. In recent few years, there were a number of works on interaction between a remote device and the smartphone, and these works also proposed methodologies that show information can be received by the smartphone within the wireless network. The Smart Signage Project has combined the gesture-based technology and the latest wireless technology to enhance phone subscriber's experience of acquire digitalized information from computerized signage.

The computerized signage and the client-end software in the smartphone play important roles in this project. The computerized signage is responsible to display a list of image chronologically and to distribute the digitalized information of current display image within the wireless network. The signage retrieves image update from the FTP server periodically, and the image update is done by the administrator using a web-based Web Tool. Through the Web Tool, the administrator can generate needed files and images in the format which is acceptable by the signage, so that he can then upload to the signage after. In order to receive the digitalized information from the signage, the phone subscriber needs to install the client-end software, called Smart Signage Phone Application, in his smartphone. This gesture-based phone application allows the phone subscriber to acquire the digitalized information from the signage by pointing at the signage with the smartphone and then performing the drag gesture.

A number of experiments have been done to test the signage signal coverage single signage and multiple signage scenarios. The framework works more stable when the signage is connected to

Internet through 3G. Additionally, the router needs to be in the perfect centre position between signages in the case of multiple signage deployment. Currently, the Smart Signage Project is still in its preliminary stages, and there are more future works that need to be done. The future works in Smart Signage Project will involve having the phone application work with multiple signage in vertical arrangements and enable the smartphones to share image in order to achieve viral marketing.

Bibliography

[CBCYKK2005] E. S. Choi, W. Bang, S. Cho, J. Yang, D. Y. Kim and S. R. Kim. Beatbox Music Phone: Gesture-based Interactive Mobile Phone using a Tri-axis Accelerometer.

[DB2008] R. Dachselt and R. Buchholz. Throw and Title – Seamless Interaction across Devices Using Mobile Phone Gestures, Proceedings of the 2nd Workshop on Mobile and Embedded Interactive Systems (Informatik 2008, Munich, Germany, September 11, 2008). MEIS'08, pp. 272-278.

[DB2009] R. Dachselt and R. Buchholz. Natural Throw and Tilt Interaction between Mobile Phones and Distant Displays, CHI 2009, April 4-9,2009, Boston, Massachusetts, USA.

[RMH2009] E. Rukzio, M. Muller and R. Hardy. Design, Implementation and Evaluation of a Novel Public Display for Pedestrian Navigation: The Rotating Compass,

[MAL2010] Mobile Art Lab. http://www.mobileart.jp/ibutterfly_en.html

[WHP2008] D. G. Wiedemann, T. Haunstetter and K. Pousttchi. Analyzing the Basic Clements of Mobile Viral Marketing – An Empirical Study, 7th Internaltional Conference on Mobile Business.

[WPP2008] D. G. Wiedemann, W. Palka and K. Pousttchi. Understanding the Determinants of Mobile Viral Effects – Towards a Grounded Theory of Mobile Viral Marketing, 7th International Conference on Mobile Business

[KH2008] E. S. Kim and S. S. Han. An Analytical Way to Find Influencers on Social Networks and Validate their Effects in Disseminating Social Games, 2009 Advances in Social Network Analysis and Mining.

[MMB2009] H. H. Ma, S. Gustafson, A. Moitra and D. Bracewell. Ego-centric Network Sampling in Viral Marketing Applications, 2009 International Conference on Computational Science and Engineering.

[VSJ2008] P. Ventura, H. Sousa, and J. Jorge. Mobile Phone Interaction with Outdoor Advertisements. Designing and Evaluating Mobil Phone Based Interaction with Public Display CHI Workshop, 2008.

[PLCH2002] J. A. Paradiso, C. K. Leo, N. Checha, and K. Hsiao. Passive Acoustic Sensing for Tracking Knocks Atop Large Interactive Displays. IEEE Sensors Journal, vol. 17, pp 1-7, June 2002.

[CHM2008] B. Congleton, F. M. Harper, J. F. McCarthy. Linking Mobile Phones and Public Displays for Sharing Online Media in the Physical Workplace. Designing and Evaluating Mobil Phone Based Interaction with Public Display CHI Workshop, 2008.

[HR2008] R. Hardy, and E. Rukzio. Direct Touch-based Mobile Interaction with Dynamic Displays. Designing and Evaluating Mobil Phone Based Interaction with Public Display CHI Workshop, 2008.

[2008KTOS] H. Koike, M.Toyoura, K. Oka, Y. Sato. 3-D Interaction with Wall-Sized Display and Information Transportation using Mobile Phones," In *Proc. Workshop on designing multi-touch interaction techniques for coupled public and private displays (AVI2008 workshop)*, May 2008.

[HM2008] E. Hildreth and F. Macdougall. Multiple camera control system. U.S. Patent 7421093, September 2008.

[N2011] J. Neff. How Mentos is still making a splash on Facebook. Advertising Age, Vol. . 82 Issue 1, 2011.

[CFKRSS2005] K. Cheverst, A. Dix, D. Fitton, C. Kray, M. Rouncefield, G. Saslis-Lagoudakis, and J. G. Sheridan. Exploring Mobile Phone Interaction with Situated Displays.Proceedings of the 1st workshop on Pervasive Mobile Interaction Devices PERMID 2005.

[YTHSH2006] K. Yatani, K. Tamura, K. Hiroki, M. Sugimoto, and H. Hashizume. Toss-It Intuitive Information Transfer Techniques for Mobile Devices. *IEICE Trans Inf Syst (Inst Electron Inf Commun Eng)*, VOL.E89-D, PAGE.150-157, 2006.