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Camera System Support For Highway Transportation Using Mobile Devices

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CAMERA SYSTEM SUPPORT FOR HIGHWAY TRANSPORTATION USING MOBILE DEVICES

by

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ABSTRACT

With the very fast growing technology in wireless, advancement in hardware and the dramatically falling cost of mobile computing devices such as PDA, handheld device, People nowadays can have a personal device that fits in their hand but has computing power as a desktop did few years ago. The same device now is able to communicate over a wireless network and view office document at the same time. The combination of size, power and flexibility makes the personal devices increasingly appear in many aspects of life.

In this proposal, we focus on a simple yet useful application of mobile devices and wireless capabilities. The application can help commuters in traffic system to find an optimal route based on video camera surveillance information. This surveillance information is made available to the user through his/her handheld devices. As an example, suppose we have installed several cameras along the expressway. If commuters can access to these cameras, they can observe the situation currently happening along the way, and decide which path would be the most effective to avoid the traffic congestion. This application will eventually improve the effectiveness of current traffic system since it will help to reduce traffic congestions.

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CHAPTER ONE: INTRODUCTION

Transportation system is always an important factor in social and economical development in any country. However, in the last few years, the demand for the use of transportation facilities has increased in a rate much higher than that can be handled by current system. The cost for building new facilities to accommodate the demand is tremendous, which leads to a new research trend to improve the existing traffic system to minimize the congestion problem. Meanwhile, with the very fast advancement in mobile devices and wireless technologies, the handheld devices with wireless capabilities are nowadays more affordable and widely used by many people. People with mobile devices now can access information in any place at any time by using the wireless network. The increasing computing power even enables them to access not only plain text information but also feature rich multimedia content. All of these phenomena have led our way to a new research in improving the transportation system using mobile devices

Assuming a driver is driving on the road, if traffic congestion happens on the driveway or he suspects that he is approaching a congestion road. At this time, there should be a way for him to avoid that traffic problem. For the time being, there are call services such as 511 in local Central Florida area that provide audio information to current traffic situation. The driver needs to call the information center to request this service. There are several drawbacks to this approach. Firstly, the audio information is not always well understood since it usually contains long and unnecessary pre-recorded information. The second drawback of this voice system is that the user can experience long delay when the information center receives a large number of requests.

If the driver at that time has a mobile device with him, he can use his PDA with wireless network capability to access the centralized system and get visual information from the camera surveillance system that is installed along the expressway. After retrieving the information, the driver should have enough information to decide which route is the best to take to avoid the on-going congestion. Thus we are arguing that visual information is better than audio information in assisting the driver to avoid congested traffic condition. In this thesis, we propose an architecture to provide that needed visual information to the driver.

Thus, we believe that, if this type of system exists, it will provide driver the most up to date and feature richness information.

In this thesis, we propose a system architecture for camera support for transportation using mobile devices.

To build this system, we identify the following challenges in realizing the system:

- The system should be able to support a large range of hardware including mobile laptops, PDAs and smart phones.

- The user interface should be as simple as possible that can be used by anyone (even person who is not familiar with using computer)

- Besides, there are major issues related to building wireless application on mobile device:

- The hardware of handheld still not as powerful as current desktop system so we can not expect it has fully capabilities of the web browser in the desktop, the form factor has small screen and limited in input make it difficult to searching and browsing web page on handheld device.

- Modern wireless network suffers from bandwidth limitation and instability.

In this thesis, we will propose a solution to solve the first and second challenges. Even though, the third problem is also an important one but we consider it as beyond the scope of our thesis.

The thesis will be organized as follows. In chapter 2 we will discuss about the related work regarding using mobile device in different application. In chapter 3 and 4, we will describe the methodology and the result we have developed in supplement to this project. Finally, we will give the conclusion in chapter 5.

Note: The project intends to use in cooperation with the Central Florida field Components project (currently develop at Florida Department of transportation). This project included field device installation, including communication, CCTV and detection equipment to help strengthen the traffic effectiveness along the expressway.

CHAPTER TWO: LITERATURE REVIEW

In the past few years, the mobile devices have been improving in many aspects, from very low computing capabilities to machines as powerful as some old desktops, from low definition mono screen to high density true color screen, from poor user interface and very bulky device to a very nice and small device, from very high cost to very affordable system.

Together with the development in hardware, we have witnessed a growing number of applications being developed for mobile and wireless devices. In this chapter, we will review several research directions related to our work. Since our system is an application, we first look at the design of some specific applications targeting users' daily activities. These include grocery shopping, video streaming, theme park touring and helping disabled people. In designing applications for PDAs, information retrieval in PDA's small screen is important, secondly we will visit the current state of the art of this research direction. One critical assumption of our design is the mobile phones can be aware of its location, finally, we review the current research related to location-aware services.

In [13], the authors design a system to assist PDA users in grocery shopping. This paper presents a good tutorial with necessary steps in designing and developing handheld applications. In another instance, Michael R. Lyu and Jerome Yen [1] try to provide users with feature rich content. They develop technologies for transmitting video contents over wireless platforms. They have designed, implemented and evaluated the iView system, a system that meets the challenge of rich, multi-modal information presentation on wireless handheld devices. They also discuss about technologies for video information management and delivery on pervasive devices over wireless networks. This result reflects that the handheld device is now mature enough for more intensive tasks. Focusing on another application, Yoshiki Ohshima and John Maloney [19] describe their process to build a customized handheld device for theme parks guests. With this type of PDA, they have provided the guests to theme parks a set of services such as digital map and index, sign post, ride reservation, playing games and even picture taking. They propose a complete solution from hardware to software for this application. The result proves that these handheld are very useful and interesting if they are widely adopted. Another interesting application is the effort to help people with motor impairment by using handheld device in [18]. The authors of this paper have developed software that allow handheld device to substitute for the mouse and keyboard on PC. This software provides a great benefit to people who lose their ability to move their wrists and arms, and therefore their ability to operate a mouse and keyboard but they still can use their finger to control the handheld computer such as a Palm. The example provides a strong impression that handheld devices are more and more appeared in every aspect of our life.

Besides research for specific applications, many others have studied how to improve the usefulness of mobile devices. One of directions is trying to improve the retrieval of information in small screen because we have known that handheld devices often have limited size of screen. In early 1992, when the handheld device was still very limited in capabilities, Stefan and Andreas have proposed a World Wide Web browser for PDAs in [9]. They point out the special requirement for PDAs as WWW clients and successfully implement a web browser for Apple Newton device. This research has led to an increasing interest in research field of web browsing facilities for handheld devices.

One solution is to re-format the content to fit in the small screen under the form of Wireless Application Protocol (WAP). In this approach, short text items that can be retrieved by navigating series of menus. Content together with the navigation structure of WAP services is specified through Wireless Markup Language (WML). Although WML offers the option of including graphics in the form of Wireless Bitmaps (WBMP), the limitation of WBMP and of most WAP browsers are such that these graphics can realistically be used to include only small low-resolution monochrome icons. Furthermore, the restricted display capabilities of most WAP-enabled mobile devices are such that a significant amount of scrolling is required to access this information and together with the use of hierarchical menus as the mechanism for navigation this makes WAP browsing into a laborious activity [34]. To remedy the limitation, in [7], Orkut and Hector have designed and implemented new Web browsing facilities to support effective navigation on Personal Digital Assistants with limited capabilities. Instead of re-formating the content to fit in small screens, they proposed a link structure allow browse pages dynamically and provide specialized pen-based navigation facilities for exploring that structure. The advantage of this method is that it does not require server-side content adjustment. However, to use the interface, it requires users a little time to get used to it.

Recently, another interesting approach to improve the information retrieval for small screen has been discussed in [15], [27], [28]. These researches have identified the value of spatially aware displays, in which a position-tracked display provides a window on larger virtual workspace. These works are based on the idea that one way to provide access to more information is to track the position of the display so it can be physically moved around to see different parts of a large workspace. However, the idea is still in research process and it has not been widely adopted for the new generation of handheld devices.

Most recently, researchers have started working on mobile device applications using location-aware services. Location-aware applications or services are those in which the location of person or an object is used to shape the application or service. At this time, perhaps the greatest enabling force behind the growth of such services is the FCC mandates that wireless carriers in the United States be able to determine the approximate location of mobile phones making emergency calls. Another enabling factor is the growing worldwide deployment of GPS devices, both in automobiles and elsewhere. As these technologies become more mature and more widespread, we could use it for other purpose. Several researches have been done in different application areas, e.g. tourist guidance [29], exhibition guidance [30], e-mail [31], shopping [32], mobile network administration, medical care and office visitor information [33]. These works have inspired us to accommodate the location-aware service as one part of our architecture for building up the camera system support for transportation using mobile devices.

CHAPTER THREE: METHODOLOGY

In this section, we will discuss about methods and techniques to design and evaluate the camera system support for high way transportation using mobile devices.

3.1 Problem overview

Revisiting our common example, suppose that a commuter is driving a car a long expressway, suddenly he realize**s** that there is potential traffic congestion happened ahead of his way. There are many signs that can make him recognize this situation, for example, the slow down of traffic or by reading the warning sign appeared along the road. At this time, he may want to know what the problem is going on and how serious it is. Normally, he can call a voice service such as 511-service (installed in central Florida area) to request the conditions along a segment of coverage area. The current conditions are then provided via recordings produced by "live" announcers located in Florida department of transportation (FDOT)'s regional traffic management center. The announcers update the conditions every 20 minutes or instantaneously if there is an incident. He will use the voice information to catch the best way to get out of potential problem. However, using this service has some potential drawbacks. At first, the driver needs to call that service; the information will be available for some coverage segment only so he will not have the overall view of the current traffic he is currently in. Secondly, the voice information provided by pre-recorded voice often supplies long and unnecessary information and it is also sometime hard to catch up. Finally, in the FDOT aspect, they need to update information every 20 minutes by using announcers, intuitively, they should not waste people effort for such kind of automatic job. Consequently, if the driver has other way for accessing current traffic situation, we can leave the burden of voice-recorded system and may provide better interactive solution for acquiring traffic information. Intuitively, we will think of a video system that provides information instead of voice information, but the question is how we can do that? The answer sometime becomes simple: we will provide video information by web service optimized for mobile device so that the driver can use his PDA with wireless capabilities to access requested information. Since the mobile devices are becoming more and more powerful and less and less expensive, the assumption that in the future every driver will carry a powerful mobile device with them is possible. We believe this system will give more interactive solution and provide better visual information for user.

However, for developing this system, we have to consider several issues: First, we need to establish a system that the mobile device can connect to and get video information. Then we have to build a client user interface for the mobile device; this user interface have to satisfy the following criteria:

- Providing useful information but restricted on small screen of mobile device.

- It has to be simple enough to control because the driver has to driver the car first.

3.2 Moving from problem to design

In this section, we will look into the consideration and design idea for the problem.

3.2.1 User interface considerations

In order to address the problem, first we need to think of being as the driver himself, what we will do when he is driving and detect the potential problem. For most drivers, they will not do anything except concentrate on the road and drive the car, other task that get too much of their attention will lead to unsafe behavior. Suppose that the driver will use a PDA instead of calling the voice service to get traffic information. Several considerations arise when designing the user interface for the PDA. First, a handheld device has different display and input affordances than a traditional personal computer system. For example, it's screen is far too small for overlapping windows to be effective. Furthermore, the driver should concentrate on driving; we didn't want to burden them with complex UI interaction such as scrolling, windows manipulation or menu selection. Finally, the PDA is often equipped with touch screen input with a stylus; he can not use both hands for PDA manipulation and forget about driving.

3.2.2 Designing the user interface

For the above considerations, we first think of two ways that help us to design it.

First, we thought about the fact that the cameras often installed at the intersection of two roads, we can give the driver a page that allow him to pick two roads, after he has chosen two road, the camera in the intersection of that two will be sent to the driver's mobile device display. We used this idea because we assumed that the driver is driving on the road, the first road he may want to choose is the road he is currently in, the second road may be the intersection ahead of him. The content of camera in ahead intersection will help him have a good picture of current street condition. If the traffic condition appears very bad, he may want to change to different road to avoid that condition. The user interface in this case may be a page that has two list of road; when the user pick the first road, all of the road that has intersection and camera with this road will be displayed on the second list. After the user pick the second one, the camera page will display content of camera in chosen intersection. By using this user interface, the driver can see camera information by few selections. Since the content of that interface is just two selection of the road, it should be fit on the handheld screen. One more advantage of this design is the download time for this interface is very fast because most of data is text. However, when thinking again, we can see that this design is not a good choice because of following two reasons. The first reason is the driver may not be familiar with the street system, he will not know about the name of the road he is currently in or the road ahead of him. When he gets to this page, he will totally be lost and our system will be not much helpful in this case. The second reason is requiring the driver to read small text and select the road in small screen may be too dangerous because his main job is driving. We didn’t want he would get too much attention on the PDA and forget about driving.

Second, it is the idea to use a map of current region for the driver to browse the camera.

Since the camera often located at a fix position at the intersection of two roads, intuitively, we can provide the driver position of cameras in actual geographic map. The driver who is already familiar with reading a map will easily find out which camera he needs to see. At that time, we may provide the driver a set of browse page with several zoom levels to zoom in or zoom out the map until he can reach the section he is currently in. In the lowest level of the map, the camera position will be display as a circle area so that the driver can select it to view the content of camera. Since the screen of camera is very small, we may also use scroll bar at lowest level for user to quickly browse a larger area of map rather than go back to upper zoom level because each of operation for changing zoom level will take consideration amount of time since the PDA need to download new data. In the camera scene, he will start receiving the picture reflect the road current condition that is sent back from camera. He may at that time can move from one camera to the other that next to it or go back to the map page to view another camera. Take into consideration that the driver will use only one hand for manipulating the PDA; we design the interface so that the camera areas are large enough for the driver uses his finger to pinpoint them instead of using a stylus to do that. This idea of user interface will give the driver a convenient way to browse the camera because he can use a graphical geographic map interface; the driver do not need to remember the road name; just pinpoint the camera position in the map and he will be able to see the camera. However, using this idea for designing interface will result some potential drawback. At first, since the graphic map is often a picture and contain more data than text data, user will need more time to download the map. Secondly, in order for user to avoid download too many level of map zoom level, we would design the size of each zoom level quite large and as a result, they may not be fit in the mobile device small screen. At that time, users have to use scrollbar to navigate through the map. That will cause very clumsy action and may not be suitable for controlling while driving car.

3.2.3 Client/server design considerations

After we have the user interface design, we need a way to communicate that interface with server to get the video information. Since the driver can use variety range of PDA running variety of operating system; for examples, one driver may use Palm OS device, the other will use windows CE based Pocket PC or Handheld PC. We didn't want to restrict access to our system by only one type of device. The server and client program should be built such that the client program can be deployed in as many different types of devices as possible. In the term when server communicating with cameras, the camera can be made from variety of vendor and they may have to be replaced after a certain time of uses; we didn't want to restrict our system to access only a specific known type of camera. We should adopt a standard interface that the system can always adapt to major hardware upgrade.

3.2.4 Designing the server

Based on the above consideration, for designing server task, first we thought of building up a web server for user access to our system. Since the user can use variety of mobile devices, it is rationale to use standard web server with standard Internet protocol for the main gateway because most of mobile device nowadays is able to connect to Internet and browse web page. We can use native application for each type of mobile device as a method for accessing our system but it will require much more work done. The good point is that native application often results in better performance comparing to web application because they have more closely interaction with the operating system. When come to special task such as closely interaction with special hardware in mobile device, the native application also win the race between the two. The down point is we may have to install the native application into mobile device before it can be used. This will cause more tedious and discourage people from using our system. For these reasons, we will adopt the web server as the main gateway. The next task would be setting up an application server for controlling cameras installed on fields. This application server will take the responsibility of interacting with cameras. Then, it can connect to a web server for publishing the camera information on the web. We will set up for each camera an fixed IP address, these IP address then will be store at a database in web server, the user interface will have link to the camera by accessing this database. When user interact with web user interface, the web server will have the responsibility to send back this address to user, later on the user will have the address of camera so he will be able to see the content of camera by going direct to it. The interaction of course will be transparent to the user; all he needs to do is browsing the interface and get information right on that interface.

3.3 Design evolution and rationale

From the initial idea, after a certain amount of time, we thought that the user interface design based on the above two idea still not good enough for the driver to use without bothering him to driver the car. So the question is: Is there anyway that can make the user interface more simple and easier to use? Let's think about the automobile Global position tracking system (GPS), when the driver is driving, his car position is constantly updated from GPS and this position will be displayed in a monitor. That mean the position of the car has been tracked by a "location - aware" service and the map software in the car has used it very effectively. So why we don’t use location aware service? First, we have thought of requiring each driver has to install a GPS system in his car before they can use our system. However, that's idea is not feasible because the GPS system is now rather expensive so there are not many drivers are willing to pay for that facilities. Luckily, after workaround, we have found out that the cellular system now offering the location service that can track the position of each subscriber. The positioning is based on identifying the mobile network cell in which the phone is located, or on measuring distances to overlapping cells. The advantage of using the cellular network for tracking the location of the subscriber is that we do not require the extra equipment such as GPS receiver.

In [20] [21], they are describing about the current and future technology of location-aware service of cellular network. According to these document, the cellular network offer three type of service: basic service, enhance service and extended service. The enhance service is the most accuracy and it can track the position of devices within 30 meters. However, it will require a more special device that supports GPS reference networks, for simpler service, the hardware requirement also lighter.

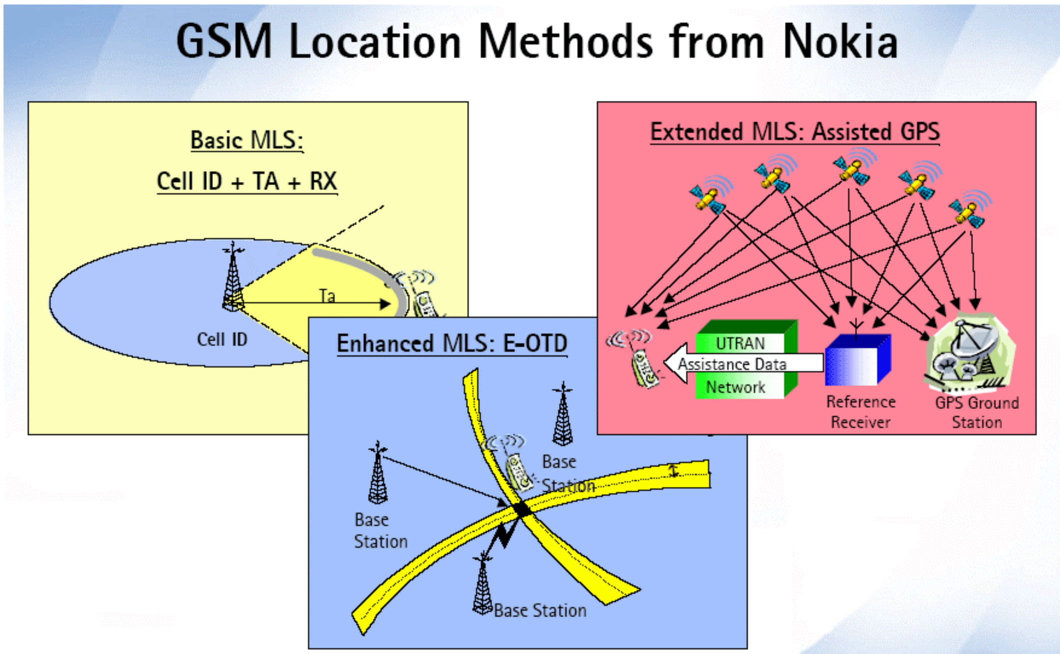

Figure 1: GSM Location methods

If we can use one of this service, for example the enhanced service (that can detect the position within 100m). Our system will be much more useful. Let's imagine that the driver with mobile phone at that time is automatically sent his position to our system. If he uses PDA and mobile phone request our service, we will use his position feed back from mobile phone as an input parameter. At that time, we can automatically detect which region he is currently belongs to; the direction of driving also can be detected easily based on the updated position. We will use this input parameter to calculate the closest camera position on the map and automatically redirect the driver's browser to that camera. As the driver moving, the content of camera window will be updated accordingly based on the closest camera. The user interface now is only the content of camera. This will result nearly no user interaction requirement.

Table 1: GSM Location technique

	Cell-id	CI+RTT+Rx	E-OTD	Assisted GPS
Typical accuracy	0.5-20km	c.a 40% improved	<100m	<30m
Terminal support required	-	-	yes, software	yes, SW&HW
Typical service area	town-specific	district-specific	quarter-specific	street corner-specific
Typical sponsor	national chain	local chain	shopping mall	individual store
Network equipment needed	GMLC, SMLC 1.5	GMLC, integrated SMLC	GMLC, integrated SMLC, LMU	GMLC, integrated SMLC, GPS reference network

When the driver wants to see the traffic condition, he just needs to push a button in his mobile device to open access to our system. Everything after that will be automatically calculated and send the feedback to the driver's mobile device.

For server side, we will have much more work done. Firstly, we will have to integrate the location-aware part to the application server. This location-aware service will get the current position of the driver, after a while, this current location will be updated, our system will calculate the direction accordingly. We will locate the nearest camera in the map based on the current position; get the address of that camera in database and forward that address to mobile device browser. The position of mobile device will be constantly tracked, when the position is moving toward another area, another camera will be located and forward to mobile device browser.

3.4 System architecture

Based on the above preliminary design, we will build up system architecture as follows:

As depict in Figure 2, we will use client-server architecture for this system. Firstly, we will have several cameras connect to an application server through cable connection. The application server will have the capability of processing all the information received from these cameras. This application server then communicates with a web server for preparing publishing camera information on the web.

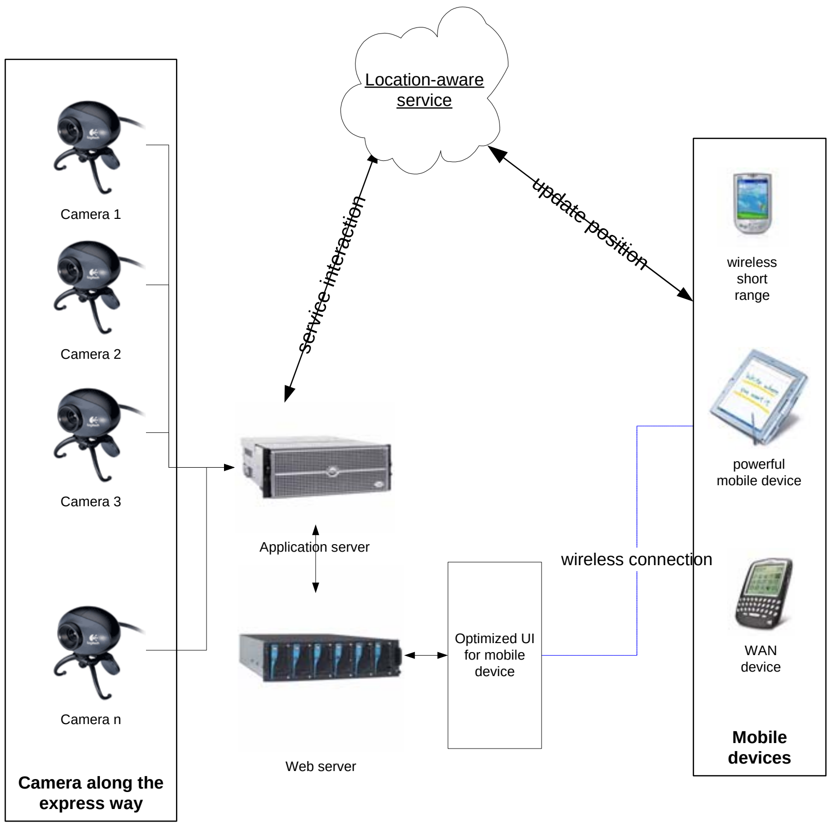

Figure 2: Transportation camera systems overall architecture

Mobile device will interact with a location-aware service. The position will be constantly updated to the service. This service will forward that position to application for further processing. We will build a web site with user interface optimized for mobile device and host it on the web server so that the user can use mobile device with several type of wireless connection to access the web site. The wireless connection can be used with wireless short range network such as Wireless LAN or wireless wide range such as GSM/GPRS or CDMA.

3.5 <u>The Pseudo-code and design flowchart</u>

The pseudo-code for this system will be described as follow:

3.5.1 The Pseudo-code

3.5.1.1 Server:

The role of server is connecting to installed cameras, setting up a socket so that a client can connect to, listening to use request and response automatically upon there is a request.

The following is pseudo-code for the server:

1. Get list of cameras.

2. For each available camera

    - Create a server socket () (By generating a port number)

    - Store generated port number to web server.

    - Connect to the camera.

    - Preparing for streaming data

   End for

3. Listening to user request of service

4. For each user request

// Get position and calculate the nearest camera

- Receiving position data of mobile user updated from a location-aware service. P_{long}, P_{lat} (Current longitude and latitude)

- Calculate the direction based on updated position

- Calculate the nearest camera in the map base on direction and current position.

// Start transmitting video stream from the camera

- Identify the correct socket.

- Create video buffer for the requested camera.

- Start streaming data to client applet through identified socket

- Stop streaming when there are no more requests

End for

3.5.1.2 Client:

At the client view, the user just has to open up the application to request the camera service. Their position will be automatically sent to location-aware service and forward to the server. The server after calculated the correct camera will be start streaming data to client.

Here is the pseudo-code for the client

1. Sending request service to server.

2. Start receiving streaming data.

3.5.2 Flowchart for client and server interaction

Figure 3 describes the interaction between the client and server.

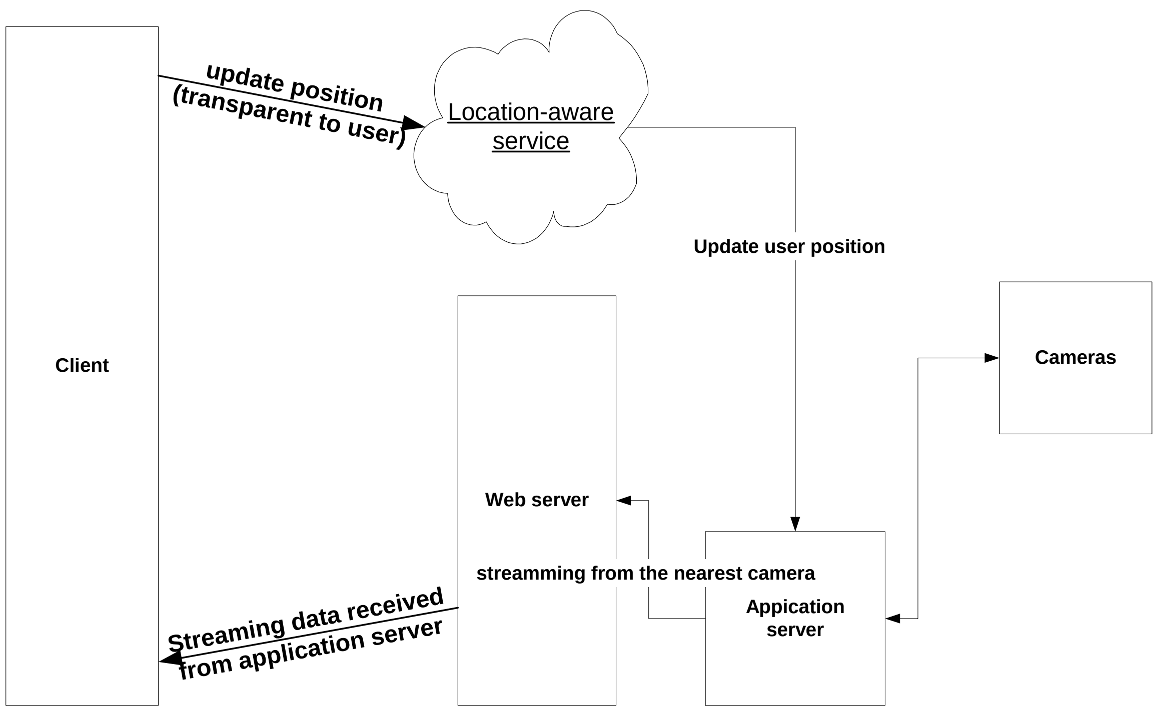

Figure 3: Client and server interaction

3.5.3 Flowchart for calculate position tracking

The following figure describes the flowchart for method of calculating the client position and forwarding the nearest camera content to client.

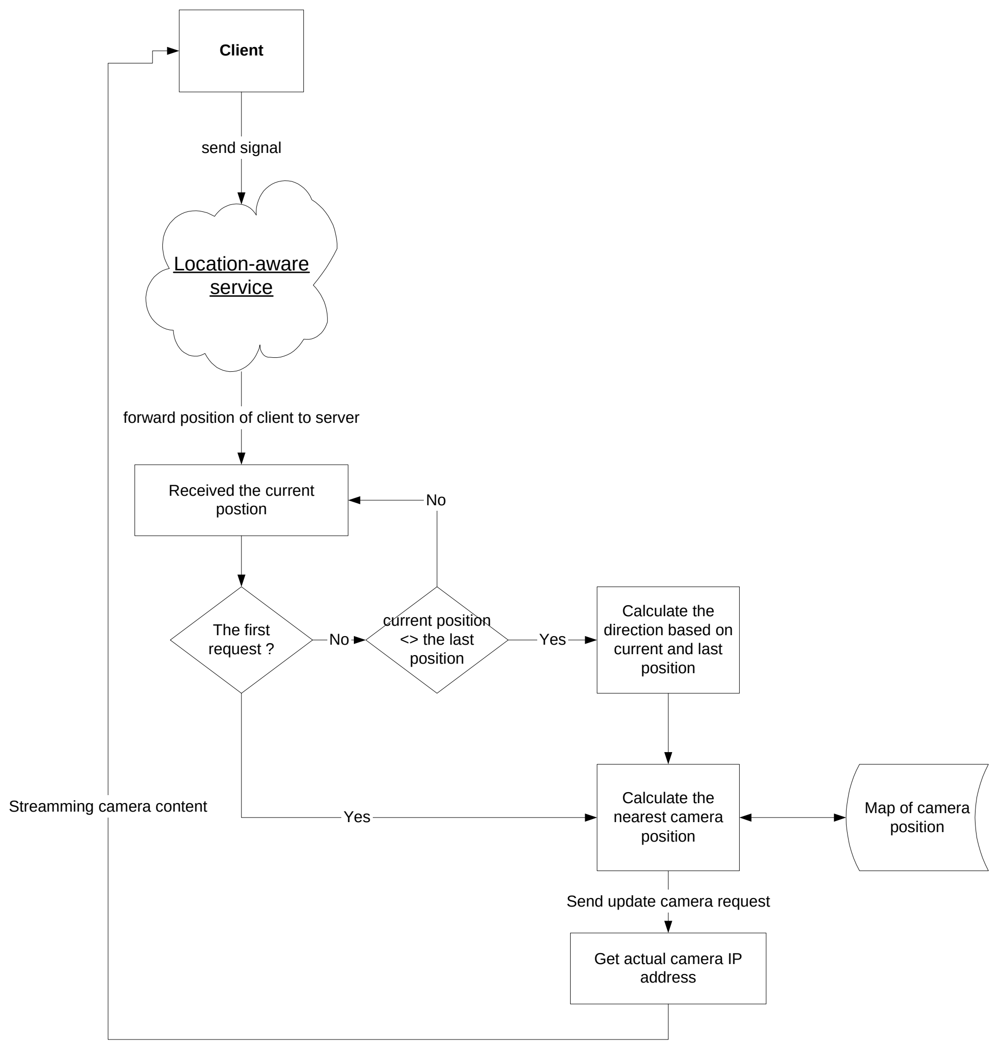

Figure 4: Flowchart for position tracking

3.5.4 Method for calculating nearest camera

Figure 5 describe the method for calculating the nearest camera based on position and the direction. From this figure, we can see that if the direction of the client is up north, the nearest camera forward will be the north camera even this client is more close to the camera because he have just passed the south camera so he will not care about it any more. The content of the north camera is likely more interested for him.

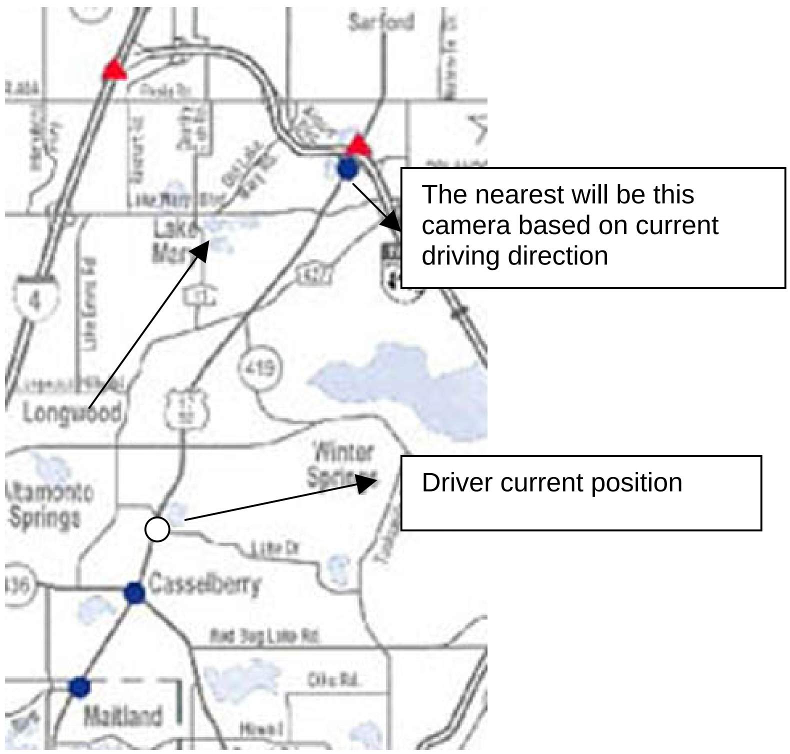

Figure 5: Demo for calculate nearest camera

CHAPTER FOUR: RESULTS

Since the current technology do not allow us to make the prototype with the support of location-aware system, we've just developed the prototype with the browse page capability and need interaction from user to test the system performance. We have tested the prototype in different wireless configuration and reveal an acceptable performance.

This chapter present the result of the experiment conducted.

4.1 Environment setup

We have tested the prototype base on the following configuration:

Table 2: Environment setup

	Hardware	Software
Server	- Computer - HP Laptop pavilion ZD7000 - Pentium 4 Processor 3 GHz. - 80 GB Hard drive storage. - 1GB Memory. - Web camera (Act as capture device) - Logitech QuickCam Pro 4000 - Veo Advanced Web Camera	- Web server: - Internet Information Server 5.0 with Active server pages support. - Application server - Java 2 Standard Edition runtime environment.
Client	- Mobile devices: - O2 XDA II pocket PC phone edition with GSM/GPRS from T-mobile service (For testing wireless wide are network performance) and integrated Bluetooth wireless. - HP ipaq 4350 with Wireless LAN built-in and Bluetooth (For testing wireless LAN network and Bluetooth short-range network)	- Web browser: - ACCESS Netfront 3.1 with JavaLite 1.2 Personal edition with Java applet support.

4.2 Technology uses

Since we want the user interface can be accessed by as many device as possible, we intent to use Java technology [22] for developing this system. Java technology has a very important advantage that it can be implemented in various type of hardware and they are now widely available for many wireless devices. In addition, the programming language is very powerful for software development so we can build the prototype for testing the usefulness of the system at shortest time. We will use Java Media Framework API (JMF) [23] for handling video and picture information from camera to the application server. JMF API is an optional package for Java 2 platform standard edition (J2SE) that provide a powerful toolkit for developer to capture, playback, stream and transcode multiple media format. When we use this package for communicating with cameras, we do not need to worry about different camera hardware but just use the standard interface. This choice will benefit when we have to install variety camera from different vendors or we may have to upgrade the cameras in future.

Then we will use Java applet technology for building client interface for user accessing video streaming. Finally, we adopt standard TCP/IP transportation protocol for connecting client and server. J2SE support standard communication very nicely.

4.3 Experiments conducted and Screen shot

At first, we need to set up the environment so that all cameras are ready to serve. They are connected to server; the server will assign each camera a port number; this port number when combine with the IP address of the server will create a socket address. A client will be use the socket for connecting to camera to get video information. In the prototype, we have provided a user interface from which a user can use a web browser from mobile device to access the camera-browsing page. The camera browsing page could be a list of road and intersection for that road, we call that road selection page - as depict in figure 6 - it is for client who is familiar with the road system and he know exactly what intersection he is interested in. Firstly, the user will chose a road; the intersection, which has an installed camera for that road, will be displayed in the next list. At this time, the user can simply click on the second road, so with only two selection, he will be able to see the content of the camera at the road.

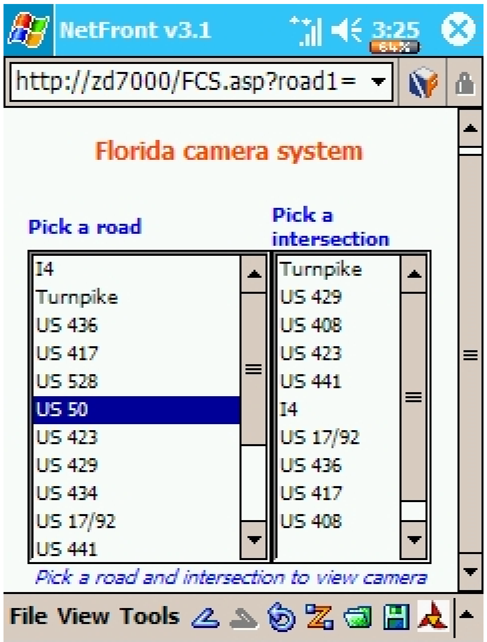

Figure 6: Camera Browse page

Alternatively, the user will be able to choose the camera from a map, we call that map page - as shown on the figure 7, blue points represent cameras installed in the express way. In this map, the user just simply picks the blue point to view the content of camera. He can navigate the map by dragging the two slider bar. This map is obviously more convenient than the road selection page but it has one draw back that the time to load the map on mobile device is longer than the time to load the road page. Thus, the user will have option to load either the road page or the map page; the decision at that time might be the available bandwidths he will have when connect to the server.

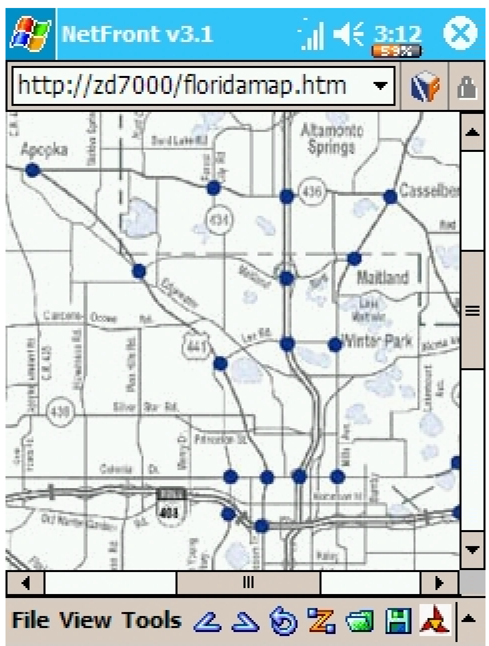

Figure 7: Camera Map page

After the user picked up a designed camera he want to see, the web server will send back a port to the clients and redirect them to actual camera page, as you can see figure 8 below, it display two different camera pages locate at different location.

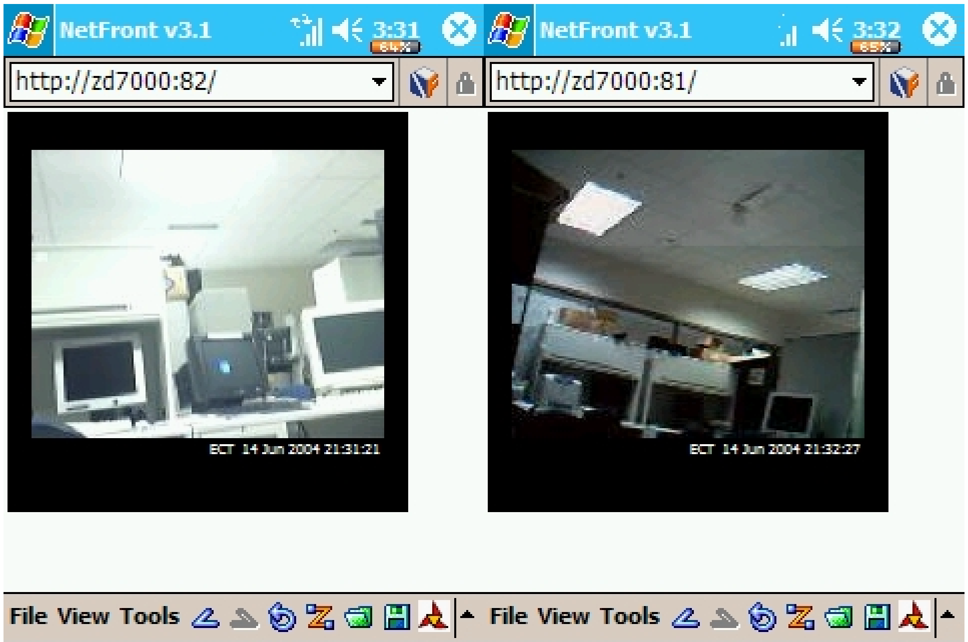

Figure 8: Camera shot at different location

The user at this time can use the picture information to identify the current traffic information at a specific road intersection. He, of course can go back to previous page to browse another camera, the picture information from the other cameras will give him a complete insight of traffic information in his area and this information may help him to avoid the traffic congestion by choosing the most convenient road.

The following table demonstrates the performance of our prototype when running on different wireless network. We have test the performance on Windows Mobile 2003 device running at 400Mhz CPU speed.

Table 3: Results of Camera system performance

Wireless network	Time to load browse page (seconds)	Time to load map page (seconds)	Time to load camera applet (seconds)	Time to update camera window
Wifi/ 802.11	<1	1	4	1
Bluetooth	<1	1.5	4	1
GSM/GPRS	1	3	7	2.5

As you can see from this table, with Wifi/802.11 Wireless LAN and Bluetooth connection, the bandwidth for mobile user is more than >300 Kbps. The time to load browse page and map page almost around 1 second. (The time also depend on the processing power of the mobile device also)

For the GSM/GPRS network; the most likely will be employed in the fields since Wireless LAN and Bluetooth will not be available in wide area, the speed to load the camera applet is 7 second and the speed to update the content in camera windows is 2.5 seconds. This result reveals an acceptable performance.

CHAPTER FIVE: CONCLUSION

In this research, we have presented a new idea that provides an alternative way for people, especially a driver on a road, to get information about current traffic situation. We can see that the system is simple to develop and ready to deploy because all the current technology has been matured enough to support it. By designing this system, we realized a benefit that the visual information is better when comparing with the sound information since people often perceive the environment by eyes rather than by ears. The driver will have a better way in understanding current traffic condition. As a result, the overall traffic problem could be decreased. In addition, our prototype has indicated that using mobile devices to retrieve information has acceptable performance by using current wireless network. In addition, with the help of location-aware service, our system will result a great benefit for the driver since we nearly require no interaction from the driver. The result will be constantly updated based on the position of the driver that will be automatically tracked by location-aware service.

After we have developed the prototype for camera support system, we have realized that there is a great possibility that our system can be implemented in the real life. One reason is that in another project funded by Florida Department of Transportation called **"Central Florida field Components project"**, several camera sensors have been installed on the expressway to provide video information for FDOT's headquarter. They use this information to control the road signal and road site. Alternatively, we could re-use these cameras for our purpose. In addition, the cost of mobile devices is falling very fast make them be more affordable for driver. We can imagine that one day, every people will carry a mobile device with them to do several different routine tasks. One of these tasks could be accessing our system to get information of traffic condition to overcome the traffic problem that is more and more troublesome for us today.

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