The Applicability of Wireless Communication in CyberTracker

Anthea Peacock
apeacock@cs.uct.ac.za

Robert Douman
rdouman@gmail.com

Lucien de Voux
ldevoux@cs.uct.ac.za

Abstract

CyberTracker is software application for mobile devices which is used for data collection. It consists of a mobile client and a desktop server. It has been used with significant success in previous years within various contexts. The most noteworthy being the collection of wildlife information in National Parks throughout Southern Africa.

The application allows users to create data entry templates which is then used to record sightings on a mobile handheld computer. When the user wishes to view reports of the sightings, the device has to be physically docked and synchronised with the desktop application. With the data already being stored electronically, it is unfortunate that the information is not available sooner.

The CyberTracker extension discussed in this paper allows for users to send data that they collect to a remote database. This functionality will eliminate the need for users to ‘return to base’ thus increasing productivity as the users’ routine will not be interrupted. The extension also allows for the possibility of having information sent from the remote database to the mobile device.

Wireless technologies such as GPRS and WiFi have been utilised in a number of different fields including medicine, field work and education. These technologies enable users to be mobile by allowing them to have access to remote databases as a means of receiving and updating information.

The CyberTracker extension implemented builds on the existing CyberTracker application by using various technologies. These include sending and receiving of information via TCP/IP in the form of structured XML packets. The extended system uses store-and-forward as a means to save collected data when a connection to GPRS/WiFi is unavailable.

Two case studies presented illustrate the usefulness of the extension. The case studies focus on the applicability of the extension by trackers in wildlife parks and traffic officers working in the UCT Traffic Department. The extended system could increase the productivity of both trackers and traffic officers by allowing them to carry out their tasks without needing to return to the office. Trackers and traffic officers can then carry on working without any disruptions of having to travel to the office. Data collected can also be available to analysts or administrators on a real-time basis thus reducing time delays of when data is available. The extended system can also be useful in terms of the data that can be sent from the database to the user. Trackers could receive information about where they have been in previous days and traffic officers could receive information about cars that have outstanding tickets.

The information presented in this paper shows that the extension to CyberTracker could be useful not only the users currently using CyberTracker but also to new users.

1. Introduction

CyberTracker is an application that affords semi-literate animal trackers the ability to convey their expertise and tracking abilities to persons who do not posses the same skills. The trackers that this system was designed for are semi-literate Khoi-San animal trackers that do not necessarily posses the ability to communicate their knowledge using the spoken word. The introduction of CyberTracker thus provides a bridge that eliminates to some degree the communication barrier between these trackers and the people with whom they are trying to share their knowledge.

The CyberTracker essentially consists of two parts, namely the CyberTracker mobile client and the CyberTracker database. The mobile client is installed and runs on mobile devices such as the Palm handheld device and the Pocket PC. This client is used by the trackers to record information pertaining to the animals that they are tracking, plants they have found and any other tracking related activities. The information recorded on the mobile device is then periodically synchronised with the CyberTracker database, which allows the game rangers access to the information recorded. As one can see in the above process, synchronisation of the database with the recorded data is determined by the regularity with which the trackers visit the database. There is thus no guarantee that the data accessed by the rangers is up-to-date.

The extensions to the CyberTracker provide a means to overcome the limitations discussed above by eliminating the need for the user to physically dock the mobile device at the database. The application allows for the remote synchronisation of the mobile device with the CyberTracker database using wireless internet protocols and XML messaging. Effectively providing the ability to have the database continuously updated as the trackers record information and have this information made available to the rangers.

This paper will discuss various benefits resulting from the ability for CyberTracker to transmit data and synchronise wirelessly with the database. We highlight the results of these extensions as well as a more detailed look at the extended CyberTracker client.

2. Background

Many applications and projects exist that consists of mobile devices transmitting and accessing information to and from a remote database. These applications and projects fulfil diverse roles in a number of different areas. The onset of wireless communication has enabled users to become mobile while still having the capabilities that they would normally have when they sit down in front a computer.

In this background various applications and projects that utilise mobile devices and wireless communication to update remote databases will be discussed.

Wireless applications have been utilised in the medical field in a number of different ways. Mobile applications often aid decision making in the medical field. When patients have to be treated or admitted, valuable information could be submitted and retrieved from a mobile application instead of relying on a desktop computer. One such system is an application that helps surgeons make decisions about organ transplants. This application enables surgeons to use handheld devices to access information about organ receivers [2]. This information is used to aid the decision of whether a transplant should happen and who should receive an organ. This is useful because on average half of the time the surgeon is not in the hospital at the time that an organ becomes available. If the surgeon is not in the hospital he or she will have to come into the hospital to look at relevant information which could waste valuable time.

Another system that operates in the medical field is one that was developed to allow doctors to access a pharmaceutical database by using a cellular phone [1]. This is helpful as the doctor can give prescriptions wherever he or she is and does not need to consult other means of information.

MET is a clinical decision support system (CSSD) used to aid clinicians [3]. When new patients arrive in a hospital clinicians are required to decide what type of treatment patients need. They are often pressed for time and may have to go to a desktop computer containing a CSSD to decide on suitable and available treatment. This could waste time especially in emergency situations. Having the system available on a handheld computer could be convenient for clinicians, as they would not have to consult a CSSD residing on a desktop computer.

Mobile applications have also been used by field workers. One system that is used in the field is ENVIT. ENVIT is a system that allows for the collection of environmental and geolocation data. The system encompasses a concept called ‘field data streaming’ [6]. This means that data is both sent and received to and from a remote server.

The data collected using the ENVIT system is configurable by the user by customizing a master database where all data gets sent. The master database resides on a field server on a laptop computer. Data can include various environmental sensor data, measurements and GPS co-ordinates. This system could aid field workers by having valuable information residing on the database sent back to them. Data can also be available at real time allowing it to be analysed right after it was collected.

FieldNote is a system that incorporates handheld computers in collecting and re-using data in the field for use in the environmental and archaeological sciences [5]. With FieldNote users can send data collected on handheld devices including FieldNotes (notes written by fieldworkers in the field), GPS co-ordinates and attribute data (such as counts) to a remote database. This could be useful to teams of field workers in that the information they collect could be sent to one database thus allowing for the amalgamation of data.

A system called C-notes uses handheld devices and wireless communication for educational purposes. C-notes is a system that aims to allow students to share ideas and take and highlight notes [4]. Student's work (C-notes) can be sent from a handheld device to a C-notes server. This system allows users to retrieve notes that were taken by their class mates.

The above applications that operate in a variety of fields shows that wireless communication can complement many different tasks by users to be mobile.

3. Extensions to CyberTracker

CyberTracker allows for semi-literate users to capture information based on the observations that they have made whilst in the field. The design of the system does not, however, limit the system to merely capture information about animals and plants. It is designed to be robust, allowing the interfaces provided to the user to be are highly configurable such that they can designed by the user with a specific task in mind. CyberTracker, however, does not handle the available technologies in an efficient manner. It does not for instance use the hardware that is available on the Pocket PC to its full potential as the Pocket PC has the ability to be used for much more than simply storing data.

Progress in mobile technologies as well as the advancement of wireless internet networks provides the perfect platform on which to further develop the CyberTracker application. The application would be able to take advantage of current technologies and enhance the manner in which the system uses the available CyberTracker database. The extensions provided overcome many of the limitations imposed on the user by the existing system, such as the need to be in the same physical location as the database in order to update it and the inability to retrieve information from the database using the mobile device.

The following discussion provides an in-depth look at the extensions made to the existing system, providing and overview of the extended functionality as well as the protocols used. These extensions will provide the ability for the remote synchronisation of the data on the mobile device with the database using the General Packet Radio Service (GPRS) as well as XML messages. The completed system would thus allow a mobile device running the CyberTracker application to record information as per usual and for the CyberTracker database to be updated wirelessly using the GPRS network.

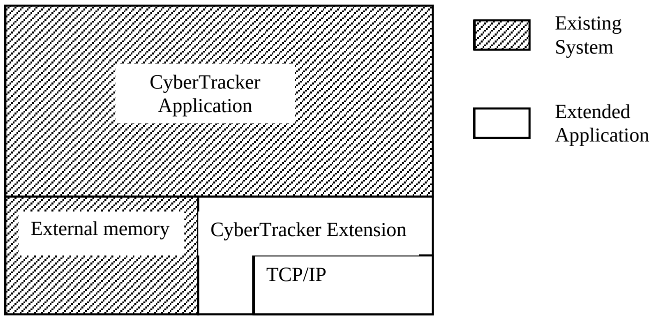


Figure 1: Overview of the extended CyberTracker mobile application

Figure 1 shows the various layers of the complete system and the manner in which these components interact with one another in CyberTracker mobile client. It shows the existing CyberTracker application communicating vertically with the extended modules which in turn access the TCP/IP network using wireless network protocols.

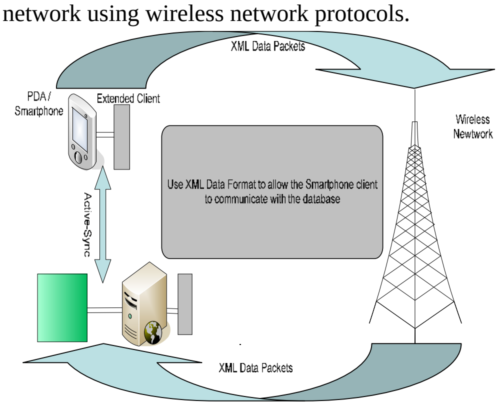


Figure 2: Overview of the complete CyberTracker system

The overview presented in figure 2**Error! Reference source not found.** shows the complete implementation of the new CyberTracker system. It shows the exchange between the client and the server using XML packets over the wireless network. There is still, however, the need to manually synchronise the mobile device with the server in order to load the desired CyberTracker sequences. This needs only to occur once when the user ports the CyberTracker sequences to the mobile device.

3.1 Implementing the extensions

Data transmission

The transmission of data was accomplished using simple c++ SOCKSTREAM sockets to communicate with the server. It encompasses setting up a TCP session with the server and allows for the simple transmission of text between the server and the client. This makes communication using the network possible in both directions, namely from the client to the server as well as from the server to the client.

3.1.1 Communicating using XML

In order to allow for greater flexibility and future expansion, all data transmitted to and from the database is done so in an XML structured packet. We have implemented a basic parser that allows for the searching of elements in a given file using only the tag name. This was deemed as the only functionality needed on the client side as far as parsing XML was concerned. The mobile client is responsible for extracting the relevant information from individual fields in both sightings and waypoints objects, converting these data structures to strings and concatenating them to the XML data packet.

Five different XML packets are used to exchange between the client and the server. These packets are: The data packet, the RTS (request to send data) packet, the CTS (clear to send data) packet, the ACK (acknowledgement) packet and the error packet. The packets are all XML formatted packets that are interpreted by the client or server as needed. Any unnecessary fields are simply ignored by the receiver of the message.

3.1.2 Timeouts and error recovery

Timeouts are used to detect network inactivity during the transmission of data to the server. The timeouts are activated when a data packet is sent from the client and reset when a data packet is received from the server or listener. When a message is sent from the client, a return message (acknowledgement) is sent from the server to notify the client to send the next data packet in the sequence of data packets. This is done in order to reconstruct the XML message on the server side correctly. The timeouts allow for messages that are lost in transit to be retransmitted, such that no information is last whilst updating the database. The specified timeout and retransmit values are critical to the correct operation of the system. A timeout that is too short will continuously retransmit data and eventually end the transmission as insufficient time for the return data would be provided. A timeout that is too long will have users waiting for absurdly lengthy periods by any notification that the required network connection has failed.

3.1.3 Store and forward

A store and forward mechanism is responsible for the temporary storage of sightings and waypoints. It consists of a vector that appends new data in a sequential manner, allowing access only to the object in the first position of the vector. Thus data is made available from the queue in a FIFO manner. Allowing access to data in this manner means the order in which data is synchronised with the database corresponds to the order in which the data was recorded.

3.1.4 The impact of the extensions to CyberTracker

The ability to communicate and remotely synchronise with the CyberTracker database allows for a broader range of applicability of the CyberTracker system. To provide a more intuitive understanding of the applicability of the new system various case studies are provided. These case studies provide particular examples of where the new system would be used and how it provides benefits that were not available with the original system. The case studies presented here make particular reference to the UCT Traffic department and the Wild Life Conservations parks.

4. Case Studies

We now consider two case studies which look at how CyberTracker would be improved by enabling wireless communication.

4.1 Case Study 1: Wildlife Conservation Parks

The existing CyberTracker application has been used with significant success in wildlife conservation parks all over Southern Africa. The application enables semiliterate/illiterate trackers to communicate information acquired using skills passed on for centuries. This capability allows them to express their findings thereby empowering them in the Western World.

The problem however is that the information collected by them is only made available at the desktop application once they tracker has returned to base and physically docked the device. It is quite unfortunate that since the data is already stored electronically, the information is not available sooner. The need to return to base is also somewhat of an inconvenience as certain animals often need to be pursued for many days.

With the sporadic availability of GSM coverage comes the possibility of having the mobile client communicate via GPRS with the desktop server. This situation would be ideal for a *store-and-forward* service. This would allow the application to store sightings when no coverage is available and have all the information sent to the server when one is available.

The trackers have the potential to never return to the location of the server but rather update it remotely. The potential benefits of this seemingly trivial extension are that animals can more accurately tracked as the trackers need never give up chase to offload information. Moreover, by having the information available to the rangers sooner, tours can be adjusted in such a way as to give the tourist as much exposure to the wildlife.

The second aspect to the extension is that information can now be uploaded directly to the mobile device from the server. This can either be done at the request of the user, or by data sent by the server. This will afford users out in the field to be provided with relevant information which may be of use to them. This type of information includes moving maps with information on where other tracker have been over the last day/week/month or perhaps being able to query a database to acquire detailed information on wildlife in their vicinity.

The other possibility is that the ranger would be able to send messages to the tracker out in the field. This service could prove extremely useful when important information needs to be passed onto field operatives who are incommunicado for extended periods of time.

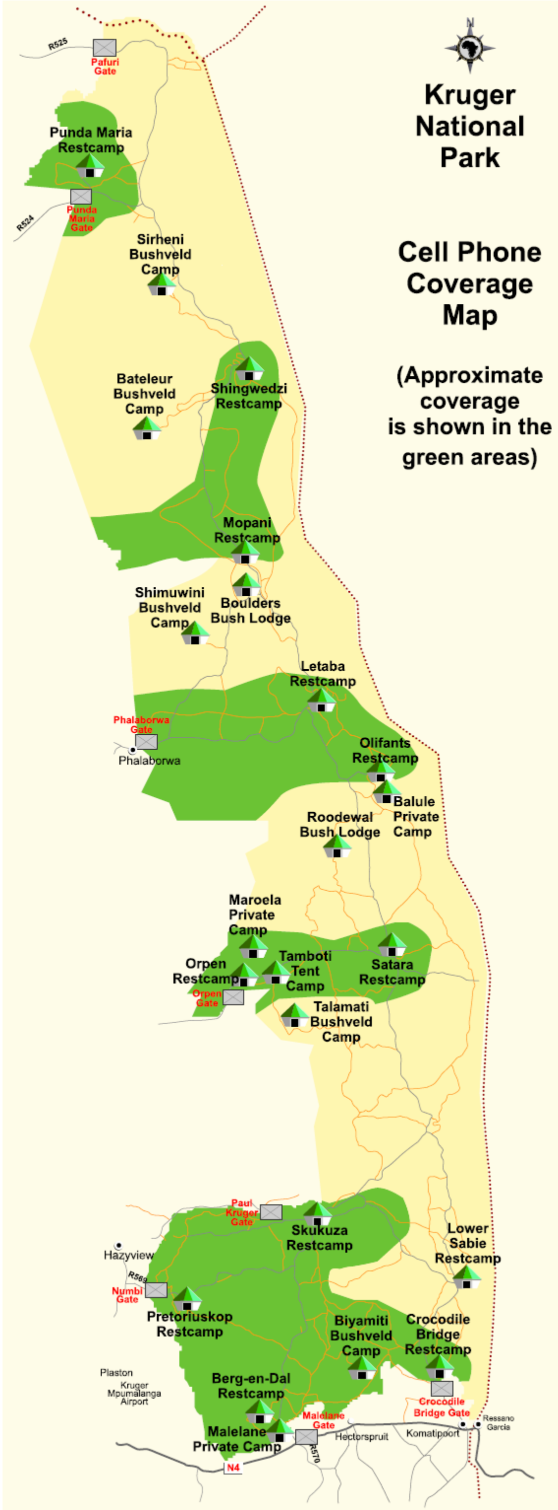


Figure 3: GSM coverage of Kruger National Park

Figure 4: Semi-Literate Khoi-San Tracker

As a future possibility, the need for rangers to have the information available out in the field has been expressed as a valuable asset. If the server were to be able to send reports to these rangers out in field, they would gain important information and respond timeously.

4.2 Case Study 2: UCT Traffic Department

The UCT Traffic Department was thought a useful organisation as they too consisted of field operatives, collecting data abroad, while others used the data at the base station. For the UCT Traffic Department, the base station is the head office situated on Upper Campus. All the records collected by the officers out in the field are captured and processed here.

A set of sequences were created for the collection of information on illegally parked vehicles[1]. The original aim of the case study was an experimental design which would provide insight into the usability of the CyberTracker extension. There were however some very interesting discoveries as to how the extension would add value to CyberTracker.

On the day of the Case Study, the traffic officers were initially observed collecting information on illegally parked vehicles using their traditional means of writing out tickets to gain information on the current system in place. Once the invigilator had spent time watching the officer, they were given the smart-phone and shown the basics of the application. The officer was then allowed to continue ticketing illegally parked cars using the handheld device (Figure 3).

The officers were evaluated using *Direct Observation* and a *Questionnaire.* An example of questionnaire and the *sequence* can be found in Appendix A and Appendix B respectively.

Figure 5: Officer "writing-up" a ticket

---

[1] The sequences titled traffic.MDB can be found on http://www.cs.uct.ac.za/~cybertracker/downloads

Observation Results

One insightful suggestion which came from the users was that it would be useful for them to know whether a vehicle had outstanding tickets or not. In fact, one user went as far as to illustrate the current procedure which entails radioing head office and having them call the database administrator. The officer then had to wait for a response and the entire procedure lasted almost 5 minutes. Moreover, the response turned out to be inaccurate due to human error. It is clear that if the CyberTracker application were able to query a database (which is one of the initial goals of the project) the functionality of obtaining outstanding tickets would then be attainable, without the need to go through any human channels. The user would be able to input a vehicle registration number and have a possible list of infractions returned to screen.

According to the manager of the UCT Traffic Department[2], this type of functionality would add immense value to the running of the department and would greatly reduce the number of outstanding fines which typically do not get paid. He also mentioned that at least one of the three data-capturers which are currently employed by the department would become redundant as the database would be updated remotely by the field officer. Another advantage that evolved from the discussion would be to utilise the application device as a "management tool" since the position and routes of the field officers could potentially be updated in real time. These could then be inserted on a moving map and used to locate employers out in the field.

Open Questions

The *most useful feature* (Appendix A, question 12) had the most encouraging answer which was from an officer who patrols Medical Campus. He suggested that the ability to send data automatically and in real time was most useful. It was later discovered that the tickets which were written up by officers on satellite campuses had to be physically delivered to the head office on Upper Campus. It is suspected that officers on campuses other than Upper Campus may find the transmission of data especially useful as they are spread out as far as Cape Town CBD.

Would having the smart-phone wirelessly communicate with the database have a major impact on the efficiency with which it is used?

It would be unfair to draw blanket conclusions from a single case study. However, it is clear that there exist applications which would find a wireless connection with the database extremely beneficial. How well the functionality is used depends entirely on the specific task and the design of the protocols being implemented.

What is for certain is that CyberTracker has a broad range of applicability and it can therefore be assumed that the frequency at which data would need to be transmitted would be task specific and depend on whether the data is required urgently or not. It would therefore be required to implement all solutions for data to be transmitted both automatically and manually.

Moreover, with the ability to wirelessly communicate between *client* and *server* creates areas of applicability which were not previously possible. These applications include those where real time synchronisation or direct communication is necessary.

[2] Mr. R. September

5. Conclusions

It has been shown that the extension to CyberTracker may be useful and add value to the current users of CyberTracker.

Wireless technologies has allowed for users working in various fields to become mobile and thus increasing their productivity. CyberTracker could lend from these instances by allowing for users to send their observations through either GPRS or WiFi. The use of these technologies may provide the users with the convenience of not having to return to base. They can then focus on the task at hand ensuring that a better job is done.

The case studies presented show that the extension to CyberTracker may be convenient for users. This convenience is illustrated by trackers in National Parks not needing to return to the office when they have made observations. In terms of the traffic officers the convenience is in terms of not having to go to head office before any processing of fines can be done.

The possibility of having information sent from the database to the user could add value to the users in the case studies. Trackers may enquire about where other trackers have been in previous days and traffic officers can enquire about outstanding fines.

It has been shown that the CyberTracker extension can provide both current CyberTracker users and new users of CyberTracker with useful functionality.

6. References:

[1] Hansen, M. and Dorup, J. Wireless access to a pharmaceutical database: A demonstrator for data driven Wireless Application Protocol (WAP) applications in medical information processing, *Journal of Medical Internet Research*, 3, 1, (2001)

[2] Krause, A. , Hartl, D. , Theis, F. , Stangl, M. , Gerauer, K. E. and Mehlhorn. A. T. Mobile decision support for transplantation patient data. *International Journal of Medical Informatics*, (2004) 73, 5, 461-464.

[3] Michalowski W. , Slowinski R. , Wilk S. , Farion K. , Pike J. and Rubin S. Design and

development of a mobile system for supporting emergency triage. *Methods of Information in Medicine 2005*, 44, 1 ,14-24.

[4] Milrad, M. , Perez, J. and U. Hoppe. C-Notes: Designing a Mobile and Wireless Application to Support Collaborative Knowledge Building. *Proceedings of IEEE International Workshop on Wireless and Mobile Technologies in Education*, (August 2002), 117–120.

[5] Ryan, N. , Pascoe, J. and Morse, D. Fieldnote: A handheld information system for the field. *In proceedings of 1st International Workshop on TeloGeoProcessing* (Lyon, France, May 1999), Claude Bernard University, 156-163.

[6] Vivoni, E.R. and Camilli, R. Real-time streaming of environmental field data, *Computers and Geosciences*, 29,4 (2003) 457-468.

Appendix A: Traffic Questionnaire

1. Age: Under 20 | 20 - 30 | 31 - 40 | 41 - 50 | 51 - 60 | Over 60

2. For how long have you been a traffic-officer (yrs)?

   Under 1 | 1 - 3 | 4 - 8 | 9 - 15 | Over 15

3. Do you own a cell-phone? Yes | No

4. Have you previously used a PDA or smart-phone? Yes | No

5. Did you enjoy using the handheld computer?
   not at all 1 2 3 4 5 very much

6. Do you think this application would be useful to other traffic officers?
   not at all 1 2 3 4 5 very much

7. Do you think the information would be useful if it could be downloaded at the office?
   not at all 1 2 3 4 5 very much

8. Would it be beneficial to have the information sent to the office when out in the field?
   not at all 1 2 3 4 5 very much

9. Would you prefer if the information were to be sent automatically without you having to decide?
   not at all 1 2 3 4 5 very much

10. How quickly did the program respond to you? **Fast 1 2 3 4 5 Slow**

Please provide a reason reasons for your answers of the following questions.

11. Was there anything which frustrated you about the program?

    ____

12. Which feature did you find most useful?

    ____

13. If you were able to remove any of the screens, which would it be?

    ____

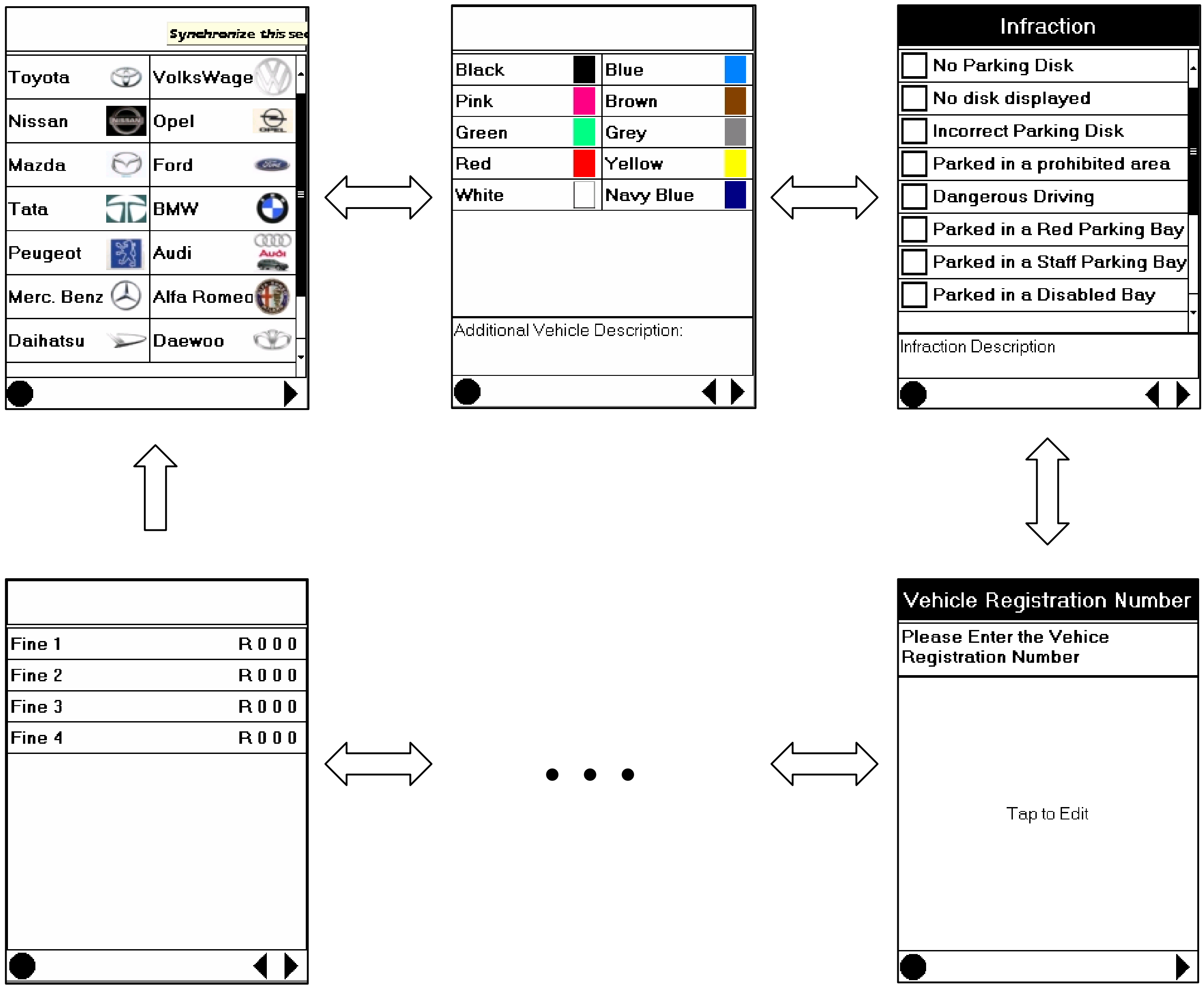
14. Would you like to decide when the information gets sent?

    ____

15. Would you like to be notified while the information is being sent?

    ____

Appendix B



Overview of UCT Traffic Department Sequence