

VANET's Infotainment Services Portal Design

by

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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

Recently, infotainment system has been used in the majority of new cars. It is considered as one of the car's specifications. Nowadays, the consumers become bored from using the traditional infotainment systems because these systems are customized for the driver and disregard the passengers who want to be able to access the Internet and keep in touch with their friends any time they want besides getting entertained through watching movies and listening to the music. This study illustrates the portal design and the features of a new infotainment system that serves three kinds of users: drivers, passengers, and children. Moreover, this system adds a new feature which allows the users to share the information, such as locations and multimedia contents, and chatting between cars using VANET services. In addition, combines many features of some famous cars' infotainment system to be in a single system and provide the passengers with some important services such as touristic services and health and safety services.

While designing in car infotainment system, there are some constraints that aim to increase drivers and passengers safety in the same time decrease drivers distraction besides offering some entertainment and provide the needed information. Therefore, this paper studies some important guidelines that should be followed in designing the user interface of any infotainment system. Furthermore, we demonstrate the three phases of the design process: discovery phase, design phase and implementation.

Using the collected data we designed a first mockup prototype that we submitted for some users' evaluation. Some problems were spotted and corrected. This resulted in the development of a first functional prototype that was implemented in iOS. This design was tested as well. We finally propose an improved version of the interface and we test it in simulation using a tablet (iPad). The different prototypes will be exposed in this document along qualitative (satisfaction) and quantitative (time) results of their usability. These results are encouraging and showed the validity of our approach.

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Dedication

“To my family: Ehab (my lovely husband) Hanan, Fathi (my parents), Najlaa, and Nadeen (My sisters)”.

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Chapter 1

Introduction

Nowadays, driving a car is not just pressing on the pedals and steering the wheels, it has become a multifunctional living space. Drivers can drive their cars in a more enjoyable and safe way by using different functions available inside them. Since many people spend at least one hour a day in a car, as either drivers or passengers, car companies compete in producing cars with efficient and usable infotainment systems in order to improve the consumers lifestyle and make their time in the vehicle more valuable [1].

The infotainment system is in the vehicle information system, and provides multiple functions such as navigation and multimedia systems, working in parallel with the moving vehicle [2]. The most important factor to consider while designing such an interface is driver safety, even before improving the systems functionality and the other features [3]. This paper proposes a user interface design and implementation for an infotainment system, by taking the advantages of some existing infotainment systems and adding other features to increase the system usability and quality, while assuring driver and passenger safety.

1.1 Motivation

Until recently, a typical car's dashboard presented the drivers with a reduced set of controls related to primary and secondary driving tasks. The primary controls such as steering wheel, foot pedals, light switches etc. gave a driver the access to basic yet essential driving functionalities, while the secondary ones provided less important features such as heat control, radio control etc. However, in the last few years we witnessed a surge in the development of new safety, comfort and infotainment features for cars such as cruise control, seat control, navigation systems, audio and video devices etc. In fact, nowadays the driver is overwhelmed by the number of functionalities a vehicle offers and as a result he is getting confused by the number of primary and secondary tasks he might accomplish while driving. In terms of Human Machine Interaction (HMI), the classical approach consisted in providing controls of these secondary functionalities through individual push buttons and switches.

However this solution showed big disadvantages and it had to be replaced by more innovative interfaces.

On the aesthetic level, filling a dashboard with buttons is a poorly appreciated solution. The current trend is to replace the traditional instruments with big and numerous displays. Also, the new futuristic dashboards are designed in a way to have a lighter configuration [4]. Moreover, an interface relying on frequent buttons usage is considered as dangerous in a car; Studies show that the multimedia features in a car are highly distracting for the driver. In fact operating audio controls and mobile phones proved to be a source of high and frequent distraction [5, 6]. Other studies on crashes [7] showed that a driver's distraction was observed in the three seconds preceding nearly 80% of the reported crash situations. The manipulations of multimedia, navigation and phone systems were identified as major sources of this distraction. This can be explained by two factors. First, when trying to use those secondary features the driver will lose his mental focus on the driving task. Second, in a buttons based interface the driver uses his visual senses to locate the controls and thus he would have to take his eyes off the road which exposes him to a great danger.

Given that, the car manufacturers had to develop safer and more efficient interfaces. Their designs incorporate a limited number of buttons and switches related to frequently used or important features and an additional menu based interface regrouping the other features. This menu can be accessed through a central rotary Knob (BMW, Mercedes, Opel, Renault, Volkswagen etc.) or a touch screen (Jaguar, Lexus, Toyota, Honda, Ford etc.). Few features can also be accessed by speech recognition (KIA, Ford) or by control buttons located on the steering wheel. However, these solutions still have some limitations especially concerning the driver's visual distraction. Our principal motivation in designing an infotainment system is to provide cars with the features and functions to meet the needs of drivers and passengers; entertain them, increase their safety and decrease driver distraction. We plan to achieve this by putting the most frequent tasks in highlight to reduce the steps needed to access a feature[8] and centralizing all the tasks and activities through a single system. Since the classic cars' infotainment system focus on the drivers need, we want to serve three main classes of users not just the driver by designing an adaptive interface with three different

modes: Driver Mode, Full Mode, and Child Mode. A mode is enabled or disabled automatically given the presence or not of passengers and the vehicle movement. Each mode has different functions and tasks that fit the needs of the user. Furthermore, the system will provide the user with certain safety measures; for example, an emergency code can be sent to the control center in case of an accident.

Most current in-car-infotainment systems features, such as listening to music or to the weather forecasts, are used regularly [9]. Therefore, giving the driver and the passenger access to the information they might need through a VANET service inside the car would be a new feature. By doing so, the user can browse the Internet, communicate with the world through social media (Facebook, Twitter, etc.), check their email and read the news. We wish to not only provide the user Internet access, but to provide personalized services by adding a service provider to the VANET. This service will offer exclusive content to the members, for instance facilitating a navigation system and a reservation procedure. In addition, the system will provide new useful information such as a traffic video feed, available through the network, and develop a high level of communication between cars by sharing information and locations. It will also allow video chat and video contact with different kinds of services such as customer services in a restaurant or a medical center. Furthermore, it will allow the user to make friends through the VANET.

1.2 Problem Statement

It is very important for infotainment system users to access in real time information about vehicle current state, traffic coincident, weather climate, emergency situations, nearest facilities, etc. while traveling, but if the access to these services causes driver distraction, the probability of accidents could increase. Therefore, safety is essential while designing in car infotainment system interface [10]. In addition, the many functions of in-car entertainment systems can easily overwhelm the driver and cause him to be distracted and frustrated. Also, the traditional infotainment systems focus entirely on the driver's needs. We must develop an adapted system that satisfies both the drivers' and passengers' needs. For this reason, our system includes three different modes that serve drivers, passengers and children. Each

particular mode includes functions that serve the particular needs of the various users. Some other systems use Wi-Fi and can be connected to cell phones to access the Internet. We recommend a system using VANET in the vehicle to allow direct access to the Internet and develop a social network among cars, allowing them to share their information and location. Moreover, consumers are interested in using in-vehicle systems that have multiple functions and features such as a navigation system, entertainment, communication, and information. Our system combines all these features. Since people like to save time by using their car's navigation system to make a reservation at a restaurant or an appointment at a medical center, our system will offer personalized services by adding a service provider to the VANET and offering special content to each member. Another goal is to always keep the user informed of all system updates and notifications, and to use voice alerts for emergency warnings.

1.3 Thesis Contributions

In this thesis work, we have the following contributions:

1. Propose a new interface design for car infotainment system differentiating between three different modes (driver, passenger, and child) in order to offer each class of users with appropriate features and functions.
2. Design, implementation, test and evaluation of a context aware filter systems, in order to filter the information given to the user. This information could be user, locations, prices and services.
3. Research the existing systems, design, implement and test an efficient, useful, and attractive user interface for an infotainment system by following the design guidelines, to obtain user satisfaction.
4. Take advantage for the VANET in order to add new functions and features that are useful for the users.
5. Design meaningful icons and get them tested and validated by the users. These icons represent various functions: (Touristic Services, Notifications, Info Sharing, Car Info, Send Video, Cultural Events, Points of Interest, Transit, and Petrol Stations). The following icons are some examples:

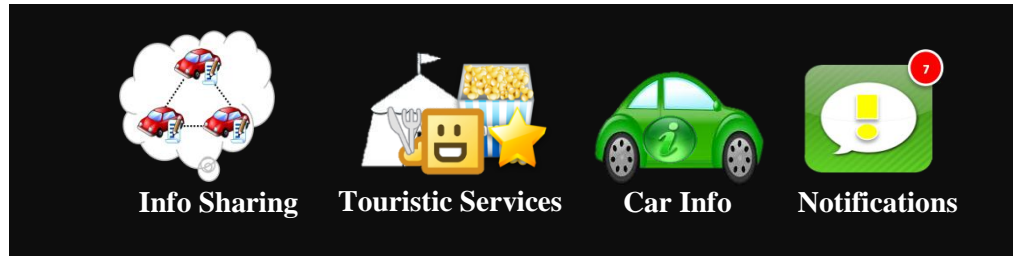


Figure 1-1: Examples of some designed icons

1.4 Thesis Overview

This thesis is organized as follows:

- Chapter 2 provides background information and related work. It covers the literature review of the history of infotainment systems, VANET, Driver Distraction, in car gestures and the infotainment system design guidelines. We also review some studies about different infotainment systems and some commercial companies: Toyota, Cadillac, and BMW.
- Chapter 3 includes the design requirements which include the data collection and documentation then explains the use cases of three different scenarios.
- Chapter 4 demonstrates the Design Phase which includes the usability test of the first mock-up prototype and the proposed solutions to the problems which resulted from the test.
- Chapter 5 provides the implementation details of the proposed system. In addition, this chapter includes the first and the second functional prototype and the usability test of these prototypes, including the test results and the proposed solutions to the problems. At the end of the chapter, we show the final interface for the three modes of the system.
- Chapter 6 summarizes the current work as well as presents a future vision of the research work.

Chapter 2

Background and Related work

2.1 Infotainment System History

The radio was the first entertainment device used in car. According to [11], Motorola invented the first commercial in-car radio in 1930. In 1952, the first in-car radio with FM. A year later, the first complete radio with FM and AM was invented. In 1953, Chrysler included a small record player in its high-end cars; it enabled the use of seven-inch records for about 45 minutes of music. Later in 1963, the first all-transistor radio was produced. Ford and Motorola cooperatively introduced the first eight-track tape player in 1965. Then, in 1969, the first in-car stereo setup was Becker's Europa. From 1970 to 1977, a cassette-tape player is introduced. In 1982, Bose was the first premium stereo system. Three years later, the first in-dash CD player was installed in Benzes [11]. Figure 2.1 summarizes the in-car radio history, until 1985.

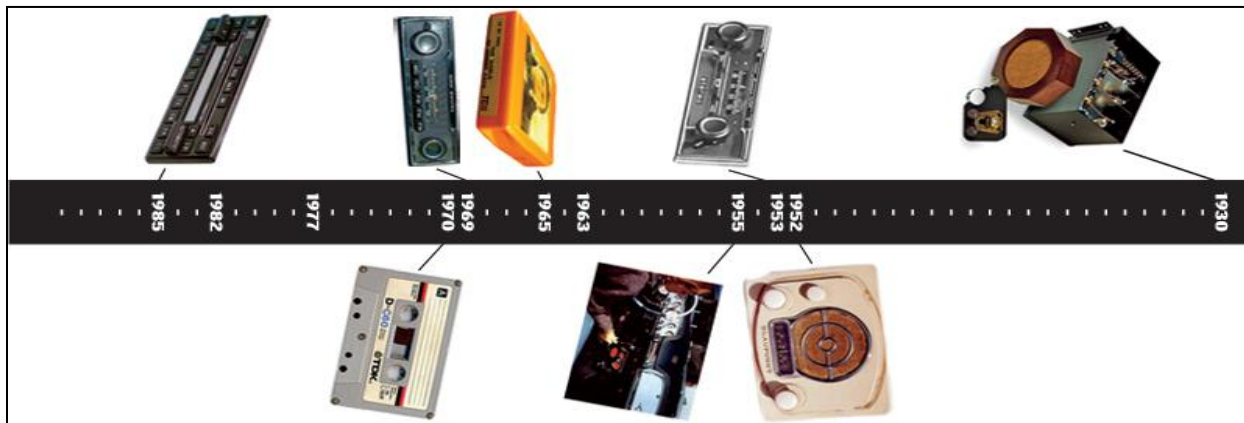


Figure 2-1: In-car radio: 1930-1985 (taken from [11])

In 2001, satellite radio goes live featuring the American country music star Tim McGraw [12]. Since 2007, people can synchronize their iPod or smart phone to the car's system by connecting these devices, via Bluetooth or hardware, to the entertainment systems available in most modern cars. Finally, in 2012, the car's infotainment system becomes a type of application as a result of the integration between radio, smart phone, and stored multimedia [12].

2.2 VANET

The using of wireless Internet and cell phone has become popular around the world [13]. Vehicular ad-hoc networks (VANETs) are a subset of MANET mobile networks and a wireless communication between vehicles to be used as network nodes [14, 15]. VANET communication has recently become a common research topic in the area of wireless networking. The goal of VANET research is to develop a vehicular communication system that provides the needed data for increasing the passengers' safety and comfort [16]. According to [17], there are two main categories of VANET applications: safety applications and user applications. Safety application is used to increase the vehicle safety on the road and can be used to warn cars of an accident to prevent car jam. In addition, these applications can give the driver the early warning to prevent the accident from happening. On the other hand, the user applications which used to provide value added services, such as, entertainment. For example, share audio or video data between roadside units or vehicles [17, 18]. Therefore, we take the advantage of VANET in the connectivity between the different users/cars on the same network in order to add new features. In addition, we take the advantage of the different sensors in the car, like GPS and speedometer, to filter the information and make the users connected on the go.

2.3 Driver Distraction

Driver distraction, "any activity that takes driver's attention away from the task of driving", is considered as an important safety problem [19, 20]. Causes of distraction can be generally classified into cognitive, biomechanical, visual and auditory [21]. Another study [22]

indicates that wireless devices such as cell phones, conversation, and in-vehicle distraction sources are the major causes for the traffic accidents. Clearly technology plays a significant role in driver distraction causes and solutions [23]. Originally, the use of mobile phones was the main distraction cause, but it seems that there are other sources of distraction inside and outside the vehicle that have similar potential impact on safety, and controlling these distractions extend well beyond law [24]. In summary, there is evidence that driving time involves potentially distracting activities and driver controls associated with radio, climate, navigation, mobile phones and CD [23]. In our proposed system, we want to reduce the distraction by proposing only the tasks that do not need too much attention from the driver, testing the different menu hierarchies in order to optimize the access time; use different type of feedback, such as audio warning, and haptic feedback, on top of the visual one.

2.4 In car gesture recognition

The use of gestures for Human Machine Interaction in a vehicle was considered as extravagant. However, with the introduction of many new infotainment features and because of the visual attention they require, this method became more realistic. A study [25] introduces a limited set of gestures based on dynamic movements. They divided their gestures into two categories: referencing and kinemimic. Based on a usability test they performed they found a high inter and intra individuals conformity. They also showed that gesture command style was more intuitive and simple than knobs and touch screens command styles [26].

In a general context, gesture recognition can be accomplished by different techniques. The most efficient and precise one is markers based; In fact reactive markers are fixed to the points of the body we want to track and their 3D positions are then estimated by triangulation using infra-red cameras. Movements can also be estimated by attaching sensors such as accelerators to the body parts we want to track. In either case we cannot apply this type of recognition in a car as it is considered as obtrusive.

The most convenient technique for a driver's gestures recognition can be realized using computer vision techniques. Most of the already proposed systems use image segmentation

and features extraction [27, 26, 28]. Classification can then be applied to determine the hands pose [26] or the movement detected [28]. Dynamic gestures can also be detected using Hidden Markov Models HMM [29, 26]. In fact, image segmentation is sensible to lighting conditions. Training and classification tasks can also be complex. In our system, we propose control by gesture for the basic most used multimedia functions.

2.5 Infotainment System Interface Design Guidelines

Designing a computer application interface is completely different from designing a vehicle application interface, since the main focus of the computer user is the interaction with the screen, whereas the driver pays full attention to the primary task of driving, and the infotainment system takes second place [1]. Thus, there are different guidelines that help designers ensure safety and usability of a vehicle information system. According to [30] safety should be the paramount concern when designing in-vehicle infotainment systems. In addition, the UI properties such as data flow, icons, font size and color, feedback, and constancy can affect the driver's degree of distraction and therefore his safety. As a result, this paper suggests three principal guidelines to ensure safety in infotainment systems:

- Make the user interface easy to use and place the frequently used functions where they can be seen at a glance.
- Use voice recognition whenever possible to reduce driver distraction. For example, when the car starts moving, the interface changes from touch screen mode to voice command mode.
- Control the driver's access to the functions and features that might distract him while driving. For instance, allowing a movie to play only when the car is in Park.

Paper [31] illustrates other important guidelines that may help in designing the interface of an infotainment system:

- Organize the system controls according to their priority and ensure that they can be accessed and operated easily.
- Avoid asking the driver to enter any kind of data while driving.

- Make the controls' designs relate to their functions.
- Make sure the controls can easily be seen and recognized in darkness and daylight.
- The distance between buttons should be sufficient to avoid pressing two buttons at once.
- Avoid using colors such as red and green or blue and yellow, which may confuse people who are color blind. Also, avoid using too many colors. The maximum number of different colors that should be used is five.
- System feedback should be concise, fitting, and timely, to allow the driver to recognize the feedback as it occurs.
- The language used in the feedback should be clear and simple and should cause very little distraction.

A study [32] adds another few guidelines:

- The system should not affect the driver's view of the road or of vehicle controls and displays.
- The driver should be able to perform the tasks in very few gestures, to limit distraction.
- Provide accurate and timely information for drivers as they execute tasks.
- The driver should have at least one hand free, to control the steering wheel, while using the system.
- Any pertinent information related to driver safety should be presented without delay.

Study [33] lists additional guidelines:

- The driver should not perform more than one task at a time.
- The system must allow enough time between the processing and the receiving of different information.
- The driver should take the time needed before starting another task.

These guidelines are useful for designing any infotainment system interface. After learning these guidelines, we have to determine what applications and functions are needed for an in-vehicle system. The following functions are used in the majority of the existing infotainment

systems, with some slight differences in their clustering. According to [2] and [33], these functions are:

- Navigation systems: it could be in the subcategories of integrated navigation, route navigation systems, route guidance systems and informative systems with location databases.
- Travel or traffic related information systems: this application provides the user with road signs and traffic information as well as incident warnings. Some systems also provide additional information such as traffic management information, road pricing and automatic transactions services.
- Safety Information: call emergency services or send emergency messages in case of accident.
- Vehicle communication systems: this system allows car-to-car communication and car-to-infrastructure communication.
- Car information: information about fuel level and prices, stock, and weather.
- Driver convenience systems and entertainment: radio, CD, telephone, music devices connected to the system, and any other function that facilitates the driver's experience.
- Communication: allow sending messages and making calls with the use of voice recognition.

The design of our system interface is based on work done in several research areas. In the following section, we explain and criticize the interface of (Entune, CUE, and iDrive) and their main functions.

2.6 Related Work

Many systems have been recently proposed to control infotainment devices in a car. The goal of all these methods is to reduce the use of human visual resources for secondary driving tasks. The recent solutions rely on four different technologies: Speech recognition, touch screens, advanced buttons and hand gesture recognition. A very intuitive solution for interaction between a driver and a car is to use the audio sensory channel. The control can

then be achieved by recognizing the driver's audio commands [34]. A paper [35] presents a nice study on usability issues concerning the in-car audio commands and provides some guidelines for this type of interaction. Speech command style was also implemented in some recently introduced cars (KIA, Ford). However this interaction style in general suffers from big disadvantages. In fact the commands interpretation can be ambiguous on the semantics level. On the other hand, a reliable speech recognition task is hard to achieve especially in noisy environments such as a car (e.g. on a highway or in a traffic jam). For these reasons, this technique is to be avoided. One of the common approaches that have been widely implemented in recent cars relies on using a menu based interface accessible through a touch screen [36] in order to handle the complexity of the multimedia systems. The first generation of touch screens were point based. In fact the user has to locate the icons or menu items on the screen using his finger tip as no tactile feedback can be provided. This type of touch screens causes a visual distraction and thus is problematic. An improvement of this interaction style was recently introduced by replacing the point based command by touch gestures command [37]. The need for visual attention was thus reduced by using an Apple's iPhone similar style of touch gestures. On the other hand this approach proved to increase the learnability, memorability and efficiency of the control system. Another study [38] integrates a multi-touch screen to the steering wheel and use finger touch gestures to control the music and navigation systems. By doing so they claim to reduce the driver's visual demand by 60%. Another evolution of a car's touch screen was recently introduced by Hyundai [39]. This new touch screen is controlled by a remote touch pad that can deliver 3D signals. Despite the improvements they bring to traditional touch screens, these methods still require the driver to use his visual senses and thus are not optimized for a risk free interaction. The secondary functionalities regrouped in menus can also be activated through the use of buttons. These buttons can be traditional ones distributed over the steering wheel in a way to be easily accessible by the driver while actively driving. A study [40] suggests using three chording keys and chording sequences patterns in order to navigate in a vision free style through the menus. However this approach requires a heavy memory load and a steep learning curve. A new type of rotary controller known as "knob" emerged recently and made its way to

different car models (BMW, Audi, Mercedes Benz etc.). The feedback to the user in this case is of visual nature. To minimize this aspect, the feedback can be provided by vibrotactile messages delivered through the knob [41]. The time spent navigating the menu can also be reduced by applying adaptive content and user modeling [42]. Despite the fact that they provide improvements in comparison to individual controls method, the reliable techniques we cite here rely more or less on visual feedback and thus are not ideal to use if we want the driver to be focused on the road. In addition, we reviewed the in car system of three famous commercial companies such as Toyota, Cadillac, and BMW. The next sections are these reviewed studies.

2.6.1 Toyota “Entune”

In 2011, Toyota, one of the biggest cars companies in the world, developed a fully integrated multimedia navigation system called “Entune” [43]. This system is “a collection of popular mobile applications and data services integrated with select Toyota vehicles”. Entune requires three main things: a suitable smartphone or feature phone, a data plan for the mobile phone, and a Toyota vehicle with Entune. Once the application is downloaded on the phone, the phone must be turned on and connected to the car with a USB cable or Bluetooth. Entune can then be accessed and controlled by the vehicle’s controls. Figure 2.2 and 2.3 demonstrate the system’s features and functions.

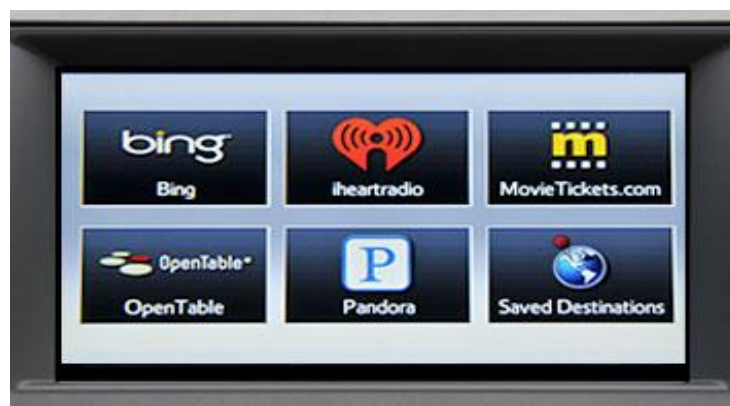


Figure 2-2: Entune Main Interface1 (taken from [44])



Figure 2-3: Entune Main Interface2 (taken from [44])

If we look at Figure 2.2 and Figure 2.3, we can analyze the design of the main interface to see if it follows the design guidelines. The color of the main interface is a combination of three colors, which is less than five, and these colors: black, gray, and blue are appropriate. The icons used are meaningful and of a proper size. The combination of images and labels is very useful. The language used is clear and simple, with the exception of “Open Table”. It would be improved by replacing it with “Restaurant Services”. The size and the color of the text are also suitable.

According to a website [44], the users of Entune can use the Bing search engine to find more than 16 million points of interest and send the destination directly to the navigation system. In addition, the system allows users to listen to more than 750 radio stations around the country via iHeartRadio. The users can search for movies and theatres, and buy tickets from MovieTickets.com. Moreover, Entune helps users find restaurants and make reservations through a service called Open Table. Another feature is Pandora which allows the creation of a customized musical playlist. Entune also allows voice recognition and responds to speech commands. One of the most useful features in Entune is access to a multitude of valued data services:

- Fuel Prices: provides the user with local fuel prices sorted by distance
- Stocks: finds the price of current stock as well as daily price disparity
- Sports: gives the user information such as scores, schedules and standings

- Traffic: provides the needed information about current traffic situations
- Weather: informs the user of current weather conditions and temperatures, and displays radar maps from around the country

If we analyze the features of the Entune system, we can see that there are many good and innovative ideas. However, some features do need improvement. For example, we find that “Open Table” and “Movie Tickets” are very useful services and great new ideas. In addition, it is very valuable to the user to get the news and be informed of traffic incidents. A feature we think could be improved is the Bing search engine. We could use a general search engine, not just one for points of interest, by enabling Internet access and adding a service provider to the VANET. Also, in our point of view, using a smart phone to connect to the system is a disadvantage. Since the phone is required to make the system work, a lost signal or dead battery can cause a problem. We think that voice recognition is another disadvantage of the system because of the differences in accents and the difficulty of recognizing the voice in noisy environments.

2.6.2 Cadillac “CUE”

We studied another new infotainment system called “CUE” which stands for Cadillac User Experience. This system is a collection of infotainment, navigation and communication tools to keep the driver fully connected [45]. The following figures show the interface design of the system.



Figure 2-4: CUE Audio (taken from [46])



Figure 2-5:CUE Navigation System (taken from [46])



Figure 2-6:CUE Settings (taken from [46])

The colors used are black for the background, gray for the icons, white, beige, or blue for the text and red for the selected button. It uses a combination of images and text to display the controls.

According to [45], the system design is distinct from other infotainment systems because it:

- Reduces the radio and entertainment control buttons to four, whereas other systems can use around twenty.
- Uses a similar interface as smart phones, for example: homepages, a minimum numbers of text, large icons, and customized information.
- Allows proximity sensing: Screen layout is clean and organized and provides the driver with the information needed. When the user's hand approaches, the icons appear and execute commands. The user can arrange and customize the controls.
- Provides haptic feedback: When the user presses on the buttons, the screen pulses in the area of the button, to confirm that the command is being carried out.
- Uses interactive gestures (swipe, tap, flick, and spread) for scrolling lists, enlarging maps or searching favorites, similar to the technology used for the iPad and the iPhone.
- Allows speech recognition: Recognizing conversation rather than only regular commands and sequences.
- Reads text messages for the driver while he is driving.
- Places the most frequently used application at the top of every screen, and is customizable so that the user can drag any favorite application to that spot.

In addition, [45] lists the other CUE features as:

- AM/FM/HD and XM radio
- 2 USB ports
- SD card
- Latest Bluetooth 3.0 hardware
- Bluetooth phone synchronization
- Bluetooth audio streaming
- Speech recognition for music, phone and navigation
- iPod integration
- Rear-facing camera, with dynamic gridlines to assist the driver when backing up
- Available BluRay rear seat entertainment

- Pandora and Stitcher availability

As a result of this study, the CUE system appears to be efficient and useful as it has a lot of new and unique features that aim to reduce the driver's level of distraction as much as possible, while providing consumer satisfaction. The haptic feedback and the option to have your text messages read to you are great. In addition, it is a flexible system that allows the user to customize features and application locations. On the other hand, speech recognition is not always an effective feature because of the diversity of accents from one person to another, as well as the difficulty of recognizing a voice in a noisy environment.

2.6.3 BMW “iDrive”

iDrive is a classic infotainment system that offers all of the traditional features of an in-car infotainment systems, as well as a number of advanced "connected" capabilities [47]. The traditional features include: navigation system, multimedia entertainment, trip computers, and information about the car's status, including needed car services and tire pressure. The connected capabilities include mobile telephone and Bluetooth. See Figure 2.7.



Figure 2-7:iDrive Main Menu (taken from [46])

iDrive uses a wheel input to control the interface and makes it easy to go from one feature to another by including shortcut keys (as shown in Figure 2.8). However, this wheel is not useful for data entry and scrolling through characters. It is therefore better to use the touch screen to enter text [47]



Figure 2-8: iDrive Wheel Input (taken from [47])

iDrive also allows voice command with a high level of accuracy and ease of use. One of the best features of iDrive, however, is the navigation system, which was one of the first build-in navigation systems that had the ability to use the full seven digit UK postcode. Maps come with top-down 2D views, and 3D views for details like landmarks and buildings, as shown in Figure 2.9.



Figure 2-9: iDrive Navigation System (taken from [47])

Another feature of iDrive is RTTI traffic data, using phone networks to provide real-time pictures of traffic accidents. In addition, iDrive allows the use of Google Maps by connecting a PC, a tablet, or a phone to the car in order to find destinations or to plan routes with multiple waypoints. BMW consumers can also stream music wirelessly via Bluetooth using any smartphone. An interesting feature of iDrive is the remote app that allows access to the vehicle's controls via a smartphone. The app does many things such as lock the doors and

show the car's location on the map [45]. There is a new iDrive feature called “Connected Drive”, which requires an Apple device connection in order to port interfaces and applications directly onto the main iDrive display [47] and [48]. See Figure 2-10.

This study showed that the interface of the iDrive System has a simple design and uses a limited number of controls, to prevent driver distraction. The wheel input is another important technique to reduce driver distraction. The system's features are useful and efficient, especially the navigation system. The idea of the Connected Drive is good, but it would be even more useful with a direct connection to the Internet.



Figure 2-10: Connected Drive (taken from [48])

Following our study of the various infotainment systems, we will take some of their advantages and add other features to create our own system, keeping in mind the infotainment system design guidelines previously reviewed.

Our ideas for infotainment systems: use the existing features and add new ones. Take the advantages of the connection between the different cars present on the same network in order to improve the user's experience. Info sharing is the new feature in our system that allows sharing different kind of information, and streaming videos and audio between cars through the network. In addition, the proposed system is an adapted system that can be in three modes: driver mode, full mode and child mode whereas the implemented infotainment systems are designed for the driver in particular. In addition, we take the idea of “Open

Table” and “Movies Ticket.com” from Entune system to be implemented in our system. Moreover, we use the idea of Internet Access to Facebook and Twitter from iDrive system.

Next chapter demonstrates the first two phases of the user interface process and the usability test of the first mock up prototype, conducts the test’s results and find the solutions of the problems.

Chapter 3

Requirements

The first phase of any interface design is the discovery phase. This phase is considered as the “collection” part, where the designer collects the information, organizes it, and documents it. This documentation explains the work process. Then there is the “interpretation” part that goes from data collection to design [49].

3.1 Collection

In this phase, we used the indirect elicitation method (i.e. questionnaire), to collect the information. We gave 20 target users a questionnaire, asking: who, what, how, and why, in regards to the infotainment system. The questions asked were intended to obtain the following elements:

- The people who are involved in the system
- What they need to accomplish their tasks using the system
- The process used by the system
- The information required to do system tasks
- The constraints imposed by the system
- The system inputs
- The system outputs

The questionnaire used contained multiple choice questions and short-answer questions. See Appendix A.

3.2 Documentation

Given the questionnaire results and the users’ answers, we were able to identify the following functions that will explain in details in section 3.2.1.1.

- Functions - the required functions for the system design are:

- Access to the multimedia (Audio, video, and photos)
- Internet Access: the user can use Google search, access to Facebook, Twitter, and YouTube.
- Call Emergency: in case of emergency, the user can call 911 by just pressing a button.
- Info Sharing: share multimedia contents, and streaming video and audio between two cars on the network.
- Touristic Services: provide different services: food, cultural event and movies.
- Navigation System: find a location direction.
- Car Information: provide the user with the needed information about the car and petrol stations and prices.
- Traffic Video Feed: the user can be able to know the traffic incident any time.
- Social Summary: summarize the social activities in Facebook, twitter and emails.
- Notifications: the user will be updated with any warning messages and received messages from other cars.
- My Schedule: to save the important dates.
- Favorite Music: save the favorite music.
- Information - the information needed to carry out the functions:
 - Audio file name
 - Video file name
 - Car name
 - Medical center name and address
 - Restaurant name and address
 - Cultural event name and address
 - Theatre name and address
 - Location name or address
- Physical - the hardware used for the design:
 - Touch based screen

- Multimedia system
- Navigation system
- Car's cam
- CD
- DVD
- USB
- Inputs/Outputs - the required inputs and the displayed outputs:
 - Inputs: text, image, audio, and video
 - Outputs: text, image, audio, and video
- Constraints - the constraints of the proposed system:
 - Minimizing distraction and increasing safety
 - Ensuring a fast and easy user access
 - Minimizing the amount of time task take
 - Using a mobile environment
- Requirements - the system requirements are:
 - Connect to a reliable network
 - Share network with other reliable members
 - Personalize services

3.3 Use Case

It is crucial to understand how to organize the collected information for it to be useful for the design phase. There are many tools that help the interaction designer during the conceptual design. A “Use Case” is one of these tools, and we use it as a way to interpret the process and data flows of the system. A use case is “a description of the possible sequences of interactions between the system under discussion and its external actors, related to a particular goal” [50]. There are two main components of use cases: actors and use cases. Actors are anything that has contact or is affected by the proposed system, whereas use cases

are the tasks or the goals the actors are involved in [49]. The primary actors of our system are: driver, passenger, and child. We can describe these actors as the following:

- **Driver:** who drives the vehicle.
- **Passenger:** who sits beside the driver or in the back seat and is over 10 years old.
- **Child:** who is a passenger 10 years old or less.

Creating scenarios is an important feature of using use cases. A scenario is a unique path through the use case [49]. We propose three scenarios to see an overview of the system features:

- **First Scenario:** A family of three members; two adults and one child, wants to travel from Ottawa to Toronto by car. They have already made a reservation at the “Sheraton Hotel”. In the course of this journey:
 1. They need to use the navigation system to find the location of the hotel.
 2. While the father is driving, he listens to his favorite song.
 3. The mother sends an invitation to the family’s friends to have dinner at “Red Lobster”.
 4. After they accept her invitation, she makes a reservation for the dinner.
 5. Their daughter is quiet because she is watching a movie entitled “The Brave”.

A use case diagram is used to represent the flow of the stated events. See Figure 3.1.

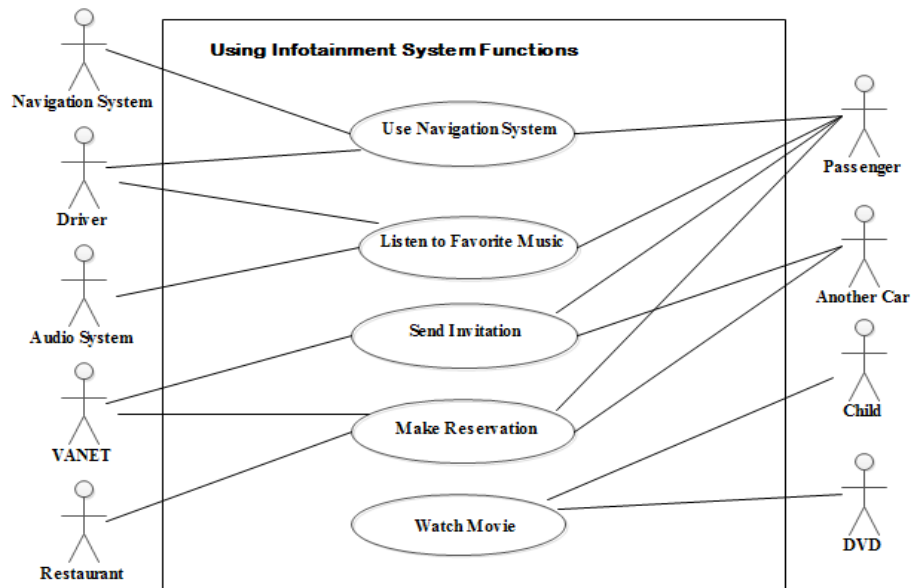


Figure 3-1: First scenario use case diagram

- Second Scenario: Once the family has travelled half of the distance, the following occurs:
 1. A warning message says “Be careful, the fuel level is low”.
 2. The father searches for the closest petrol station using the Petrol Station function.
 3. The father uses the Traffic Video Feed to know about the traffic jam.
 4. While they are on their way to find a gas station, they see an accident on the road and call emergency.
 5. The police and ambulance come.
 6. The family continues driving and finds a gas station.

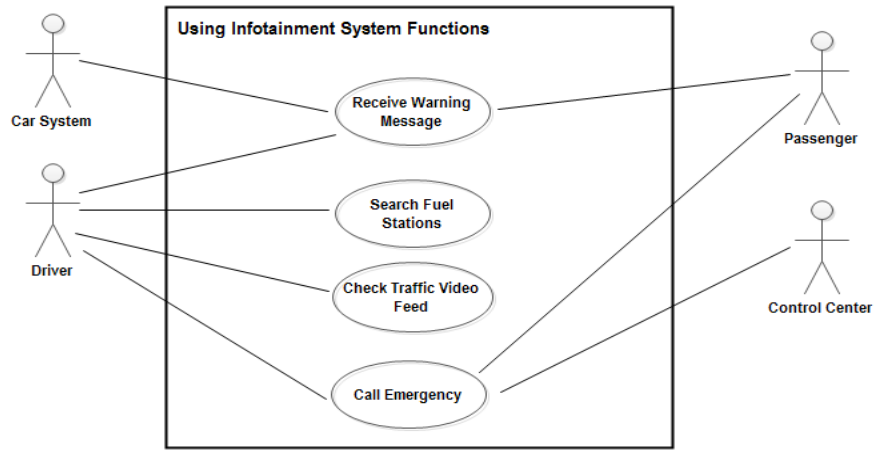


Figure 3-2: Second scenario use case diagram

- Third Scenario: When the family arrives in Toronto:
 1. The mother uses “Info Sharing” to make a video call to her friends who live in Toronto.
 2. The mother uses the system to find the location at which to meet her friends.
 3. The mother takes a picture of the family.
 4. The mother sends the photo to her neighbor’s car in Ottawa.

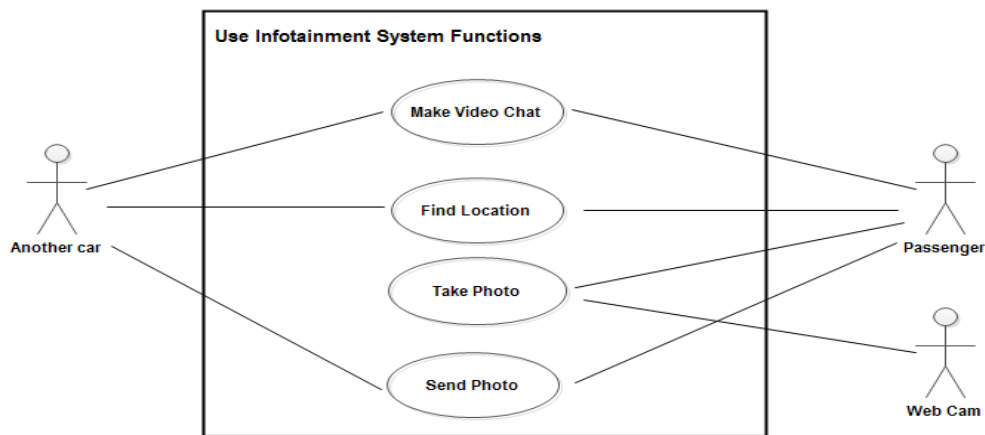


Figure 3-3: Third scenario use case diagram

In the next chapter we take the collected information and the design requirements to start the first mockup design.

Chapter 4

Design

This chapter demonstrates the design phase after collecting the required information. This phase consists of two important parts: the conceptual design and the physical design. In the conceptual design, the information space of the system design is organized and various ideas are tested to decide which ones meet the system requirements [49]. In the physical phase, prototypes of specific design solutions are designed and evaluated to see if they match design principles [49].

4.1 Conceptual Design

In this part, we develop different ideas to determine how the design performs and how to provide various functions to the user.

We propose design solutions that meet the system requirements and take into account the system constraints:

- Make three different modes: driver, child and full. Each mode includes functions and processes suitable to the needs of the user. For example, the driver functions are limited to those that help in the task of driving and that help reduce distraction.
- Prioritize the information and provide it in a quick and effective way.
- Minimize the number of menu items in the driver mode.
- Use big and meaningful icons.
- Use different cues such as labels and voice alerts to display the information.
- Assume that there are sensors on the seat to be able to know the occupied seats.
 - If only the driver is in the car and the car is moving, only the “Driver Mode” is available, to ensure safety.
 - If there is an additional passenger or if the car is in Park, we allow different kinds of modes.

- Provide different types of notifications that could also be used as voice warning for emergencies.

4.1.1 Analysis

As a result of the discovery phase, we can summarize the main functions of the proposed system in the following table, sort these functions by priority, and describe which functions are associated to each mode.

Function	Description
Call Emergency	In case of emergency, the passenger and the driver can press the Call Emergency icon to start a video call with the control center. This function is very important and available in all screens and for all modes.
Navigation System	<p>This function allows drivers and passengers to:</p> <ul style="list-style-type: none"> • Search Address: the user has to enter the address, name or postal code of the desired location. • Search Points of Interest: the user can search for the location of a restaurant, transit, fuel station, bank, shopping center, etc. • Use Favorite Locations: the user can navigate any location stored in the Favorite Locations folder. • Use Recently Found Locations: if the user wants to review recently visited places, they can search the Recently Found Locations folder. • Go Home: gives the user the directions to go home. • View Map: allows the user to view the current map. <p>This function is available for driver and full modes.</p>
Health and Safety Services	<p>This function provides the user with:</p> <ul style="list-style-type: none"> • Health and Safety Information: provides the user with important health related information. • Health Institute: user can search for a medical center and find all the required information such as location, contact info and map location. • Fire and Rescue Services: in case of fire or of other serious risks, the driver or the passenger can call the fire and rescue services, or send a message code to control center. They can also view some instructions about fire and emergency rescue.

	This function is available for full mode.
Notifications	<ul style="list-style-type: none"> • Always keep the user informed with system updates and car maintenance updates. These messages could be a warning about : fuel or oil level, tire condition, temperature, receiving invitations, accepting or rejecting invitations, asking location permission, accepting or rejecting location sharing permissions and receiving audio, video, or photo. • The user can decide to view the warning messages immediately or to keep them for later, in which case they will be added to the Notifications list. • If the warning message is an emergency warning, the system will block everything else until that problem is solved. <p>This function is available for driver and full modes.</p>
Traffic Video Feed	<p>This is a useful function especially for the driver, to allow him to know about current traffic situations. For example, which route is backed-up with traffic and which route is clear.</p> <p>This function is available for driver and full modes.</p>
My Schedule	<p>Save important dates, meetings, and reservations.</p> <p>This function is available for full modes.</p>
Local Multimedia	<p>When the user wants to be entertained, they can use local multimedia:</p> <ul style="list-style-type: none"> • Audio System: listen to the radio, CD, or Digital Audio saved in the system, and the child can listen to CD or Digital Audio. • Video: watch videos either from the DVD or from Digital Video saved in the system. • Photo: take pictures using the car's cam and save them in the photo gallery. <p>This function is available for all modes.</p>
Internet Access	<p>Through VANET, the user can access the Internet to:</p> <ul style="list-style-type: none"> • Use Search Engine: use Google search engine to brows any page on the Internet. • Access Social Media: access social networks such as Facebook, Twitter, YouTube, and Video Chat. • Check Email: check email inbox and send email. • Read the News: read the world news, national news, sports, and stock and climate changes.

	This function is available for child mode and full mode.
Touristic Services	<p>This function includes three main services</p> <ul style="list-style-type: none"> • Restaurant Services: the user can search for a restaurant, take the contact information for the chosen restaurant, check the menu, make a reservation, send invitation to another car, and view map for the selected restaurant. • Cultural Event Services: the user can search for an event, take the contact information for the chosen event, make a reservation, send invitation to another car, and view map for the selected event. • Movie Ticket Services: the user can search for a theatre, take the contact information for the chosen theatre, check the movie time table, watch trailer, buy tickets, send invitation to another car, and view map for the selected theatre. <p>This function is available for full mode.</p>
Info Sharing	<p>Allow information sharing between cars using VANET services, so they can:</p> <ul style="list-style-type: none"> • Chat: allows video and text message chat between two cars. • Find Location: cars can share their location after obtaining each other's permission. • Send Infotainment: allows sharing of different kinds of infotainment such as audio, video, and photo. <p>This service is available for full mode.</p>
Car Info	<p>The user can verify :</p> <ul style="list-style-type: none"> • Car Maintenance Info: allows user to check tire condition as well as petrol and oil levels. • Check Petrol Info: provides petrol price and the closest fuel stations. • Check Traffic Information: provides current traffic updates and reports. <p>This function is available for full mode and driver mode.</p>
Social Summary	<p>Summarizes all the social activity in Facebook, Twitter, and email. This function is available for full and child modes.</p>
Favorite Music	<p>The users can save their favorite songs from radio, CD or digital audio into the Favorite Music database. This function is available for all modes.</p>

Table 4-1: Task analysis

We use Data Flow diagrams, and Interaction diagrams to represent the data flow of the system and the system interaction with the external entities.

4.1.2 Data Flow Diagrams

We use data flow diagrams to represent the flow of the information through the system, and we define context level, level0 and level1 for the system as illustrated in the following diagrams:

4.1.2.1 DF Context Level Diagram

This diagram shows all the input, output, the user and the external entities which are: the system users (driver, passenger and child), another car, Medical Center, Restaurant, Cultural Event, and Theatre.

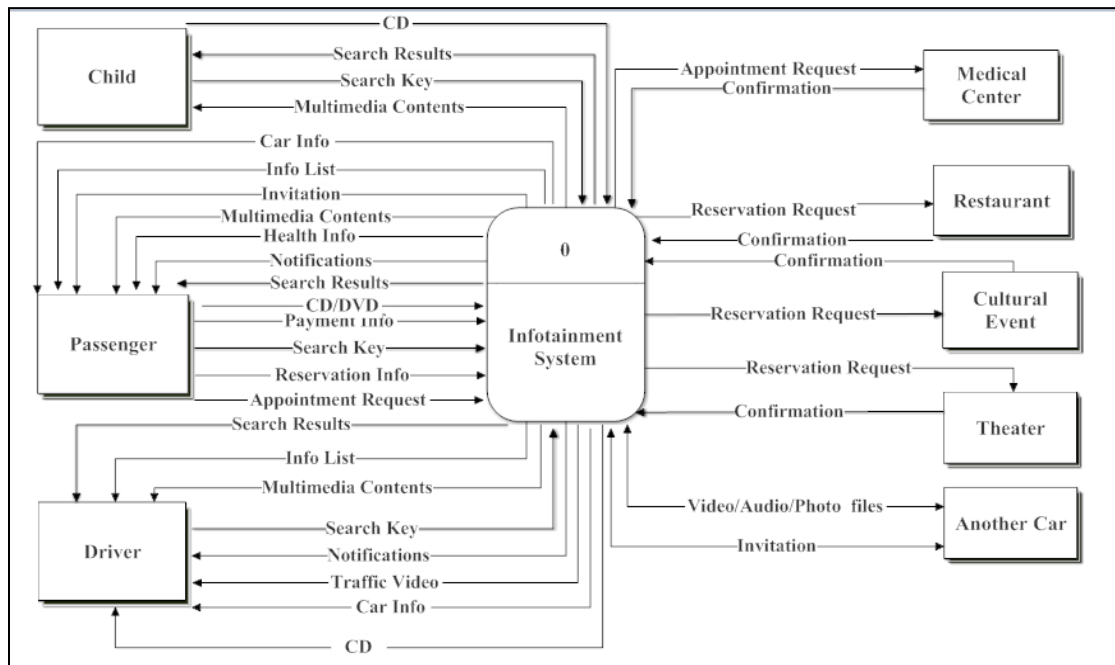


Figure 4-1: DF Context Level Diagram

4.1.2.2 DF Level 0 Diagram

Level 0 diagram shows the data flow between the sub process of the system and the external entities. Figure 4-2 shows the data flow between three main entities of the system and the other external entities through the proposed system and describes the data flow of each function of the system in details. These functions are: Local Multimedia, Internet Access, Info Sharing, Touristic Services, Navigation System, Health and Safety Services, and Car Info.

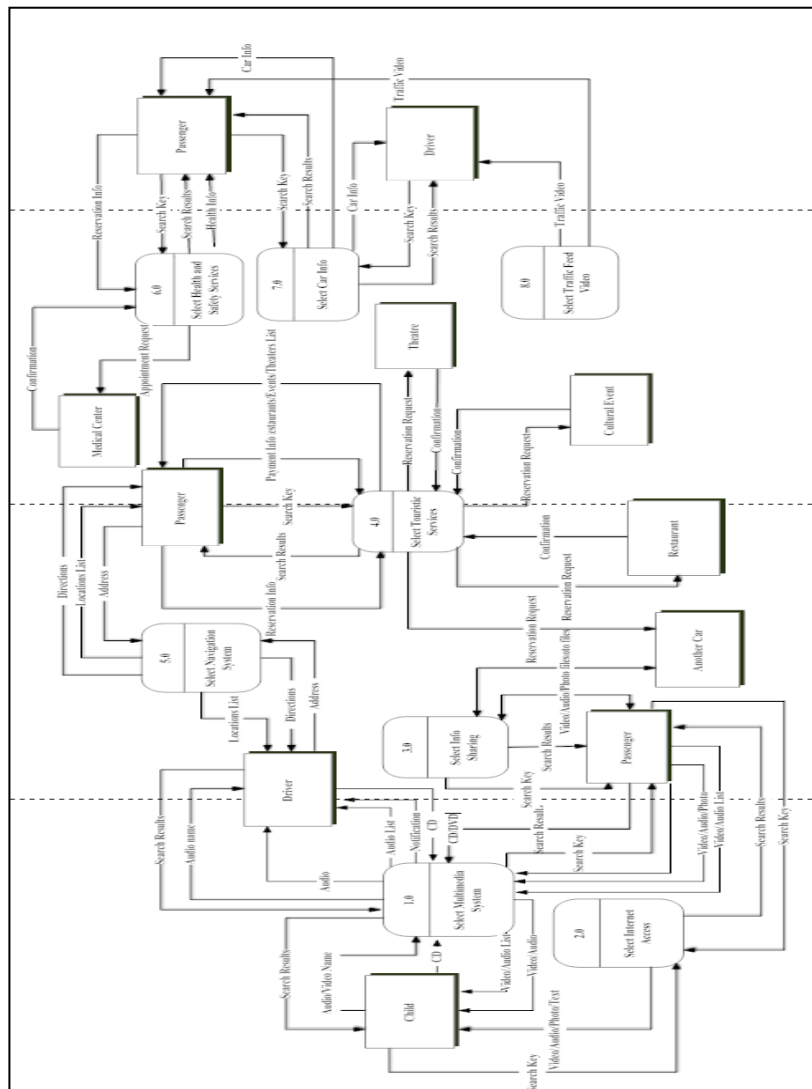


Figure 4-2: DF Level 0 Diagram

4.1.2.3 DF Level 1 Diagrams

Level 1 diagram explains actual data flows and the used data storage.

- **Local Multimedia Diagram:**

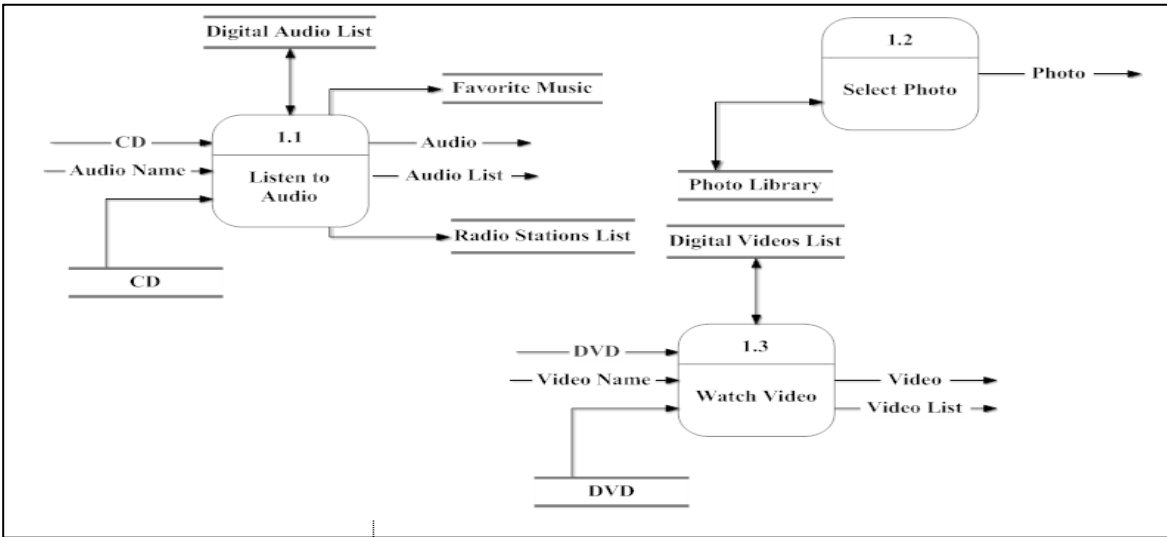


Figure 4-3: DF Level 1 Local Multimedia Diagram

- **Info Sharing Diagram:**

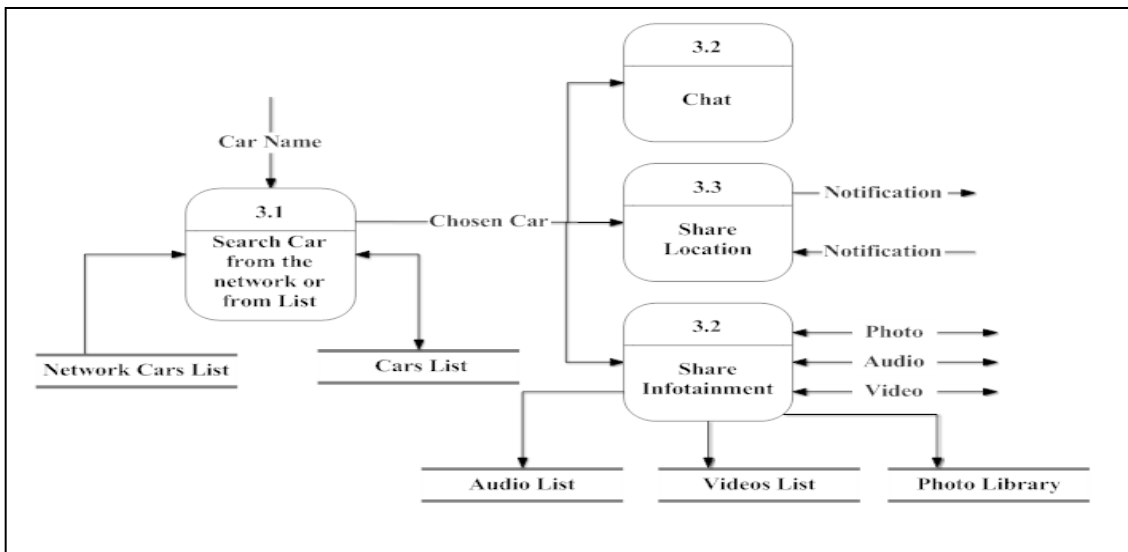


Figure 4-4: DF Level 1 Info Sharing Diagram

- **Touristic Services (Restaurant Services):**

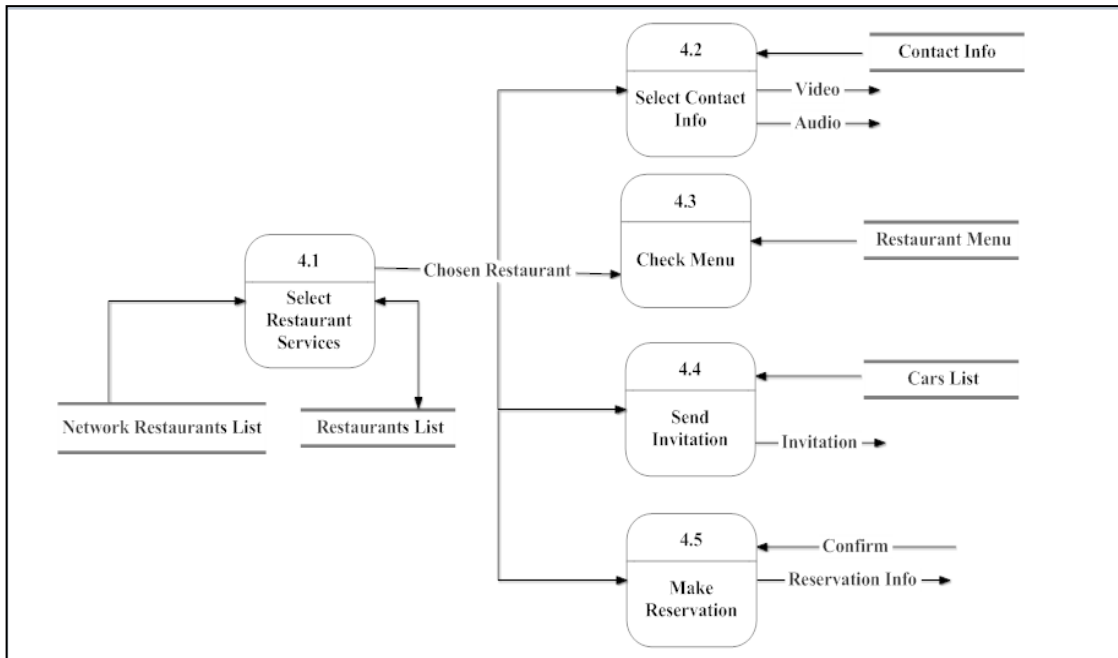


Figure 4-5: DF Level1 Touristic Services (Restaurant Services)

- **DF Level 1 Navigation System Diagram:**

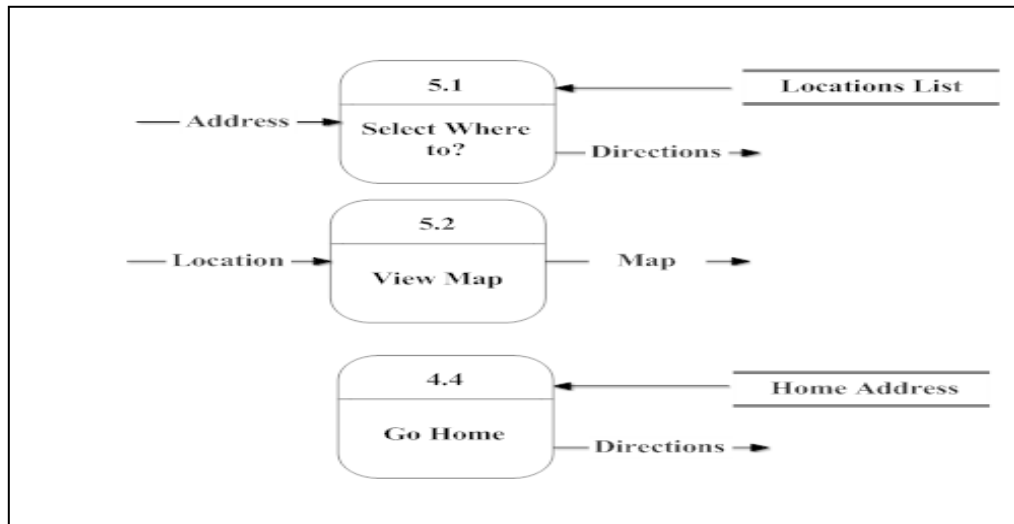


Figure 4-6: DF Level 1 Navigation System Diagram

- **Health and Safety Services:**

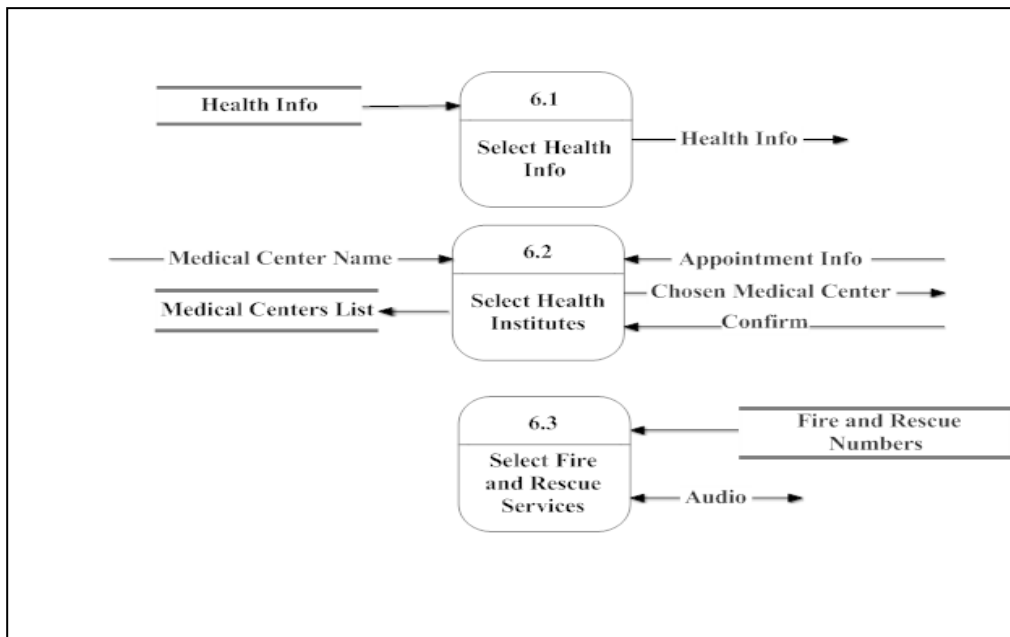


Figure 4-7: DF Level 1 Health and Safety Services

- **Car Info:**

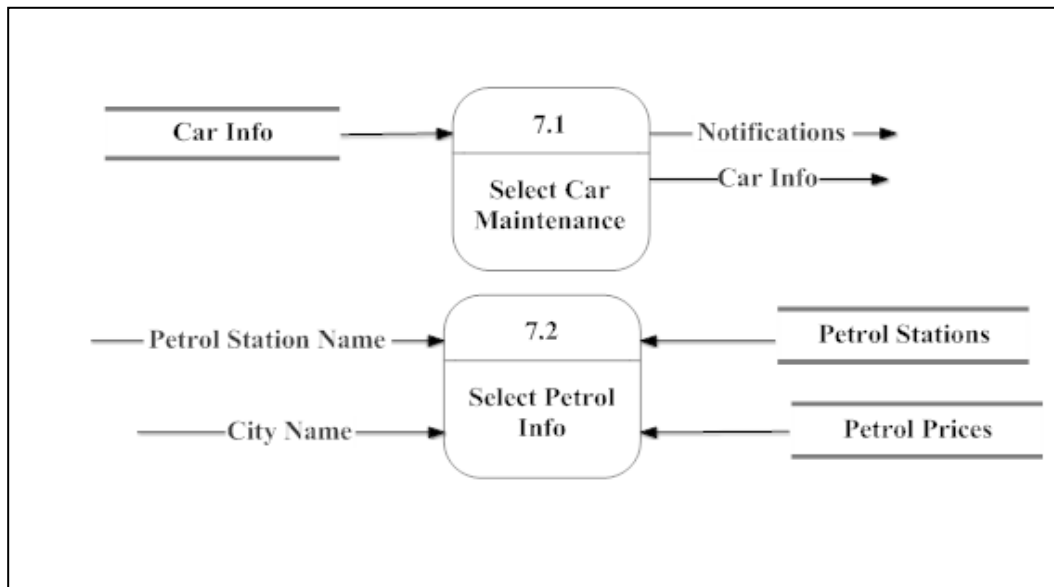


Figure 4-8: DF Level1 Car Info

4.1.3 Interaction Diagrams

We use interaction diagrams to represent the interactions for some of the new system features such as Info Sharing, Restaurant Services, and Movie ticket Service.

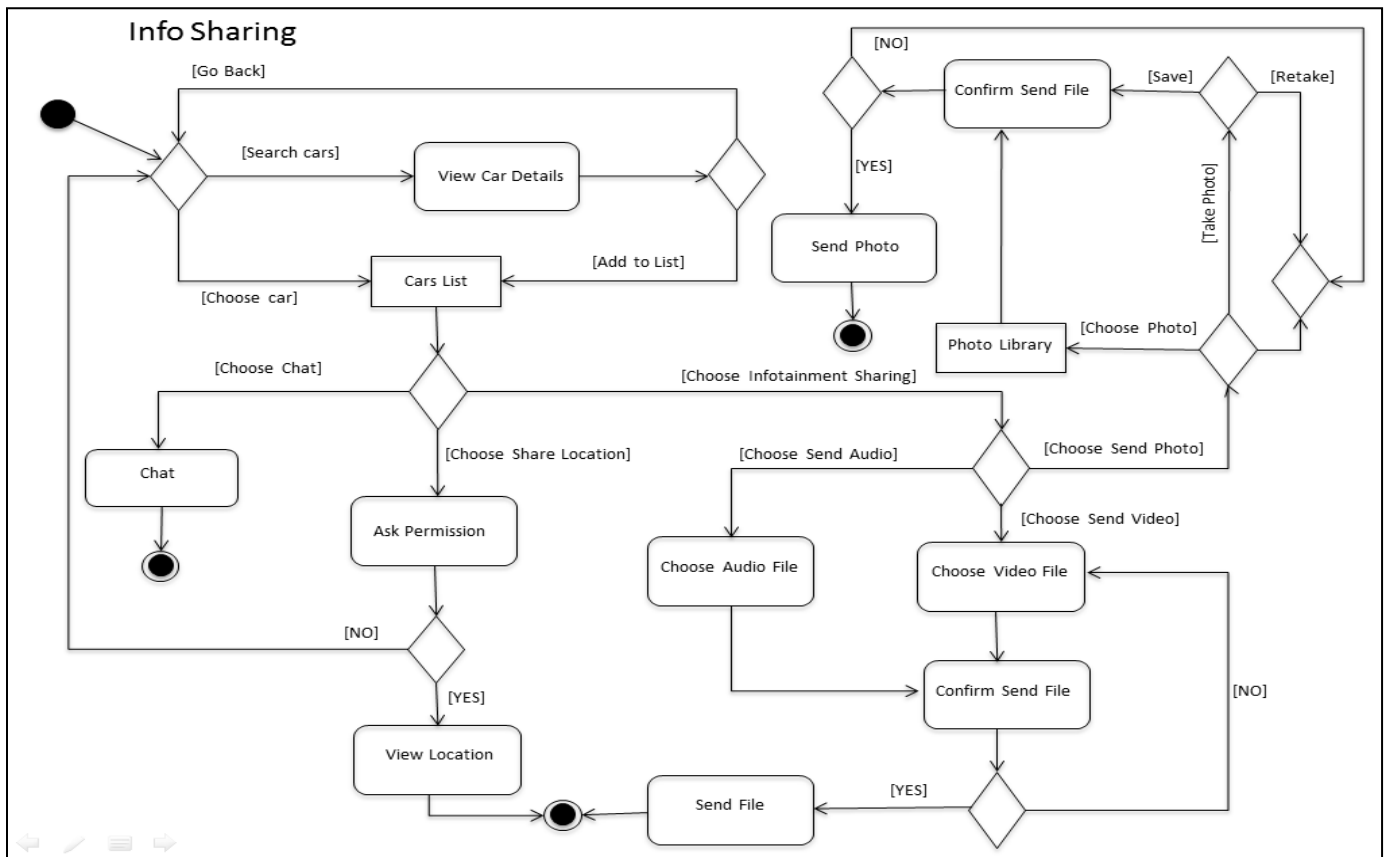


Figure 4-9:Info Sharing Interaction Diagram

When users choose info sharing function, they can either search for a car and add it to the list or choose one of the cars list and do one of the following: streaming video with that car, sending infotainment file or share the location after taking the permission from the chosen car.

Second, from the interaction diagram of “touristic Services”, we choose Restaurant Services and Movie Ticket Services.

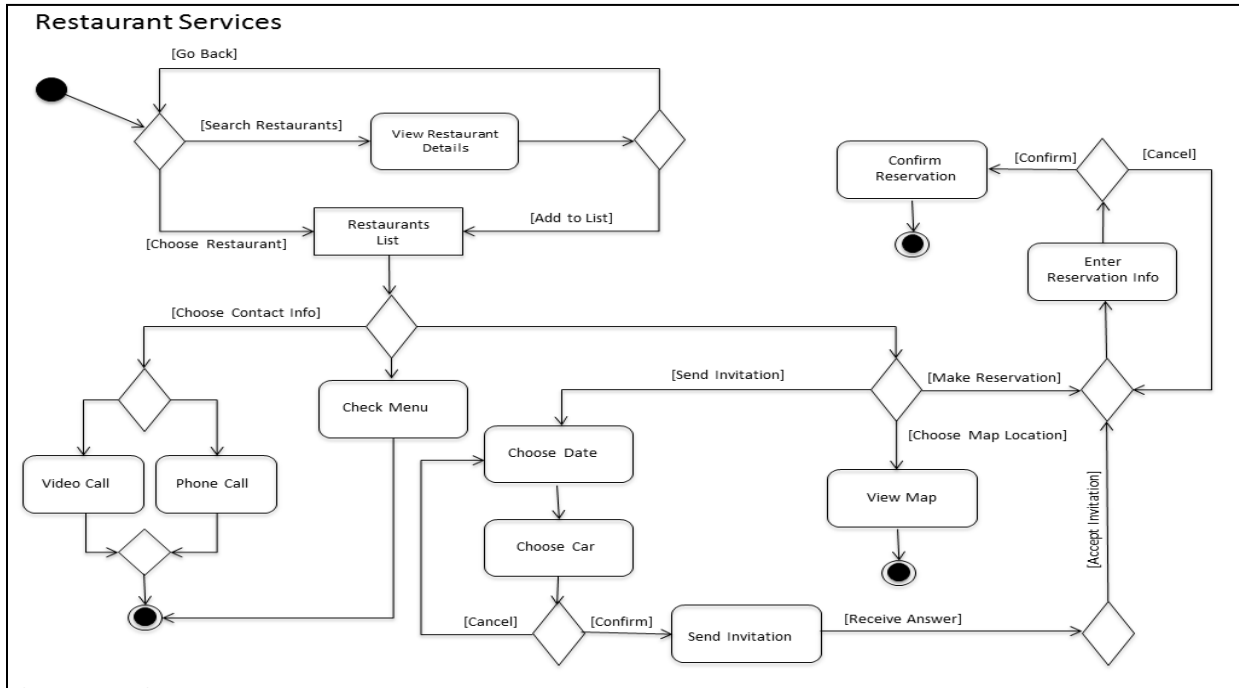


Figure 4-10: Restaurant Services Interaction Diagram

In Restaurant Services, the user can search for a restaurant and add it to the list or choose one of the restaurants from the Restaurants List to do the following tasks:

- Make a video call or phone call with the restaurant
- Find the map location of the restaurant
- Check the menu
- Send Invitation by choosing the date and a car from the cars list then confirm sending
- If the chosen car accept the invitation the user can make reservation by entering the required information and click confirm to confirm the reservation or cancel to cancel the reservation

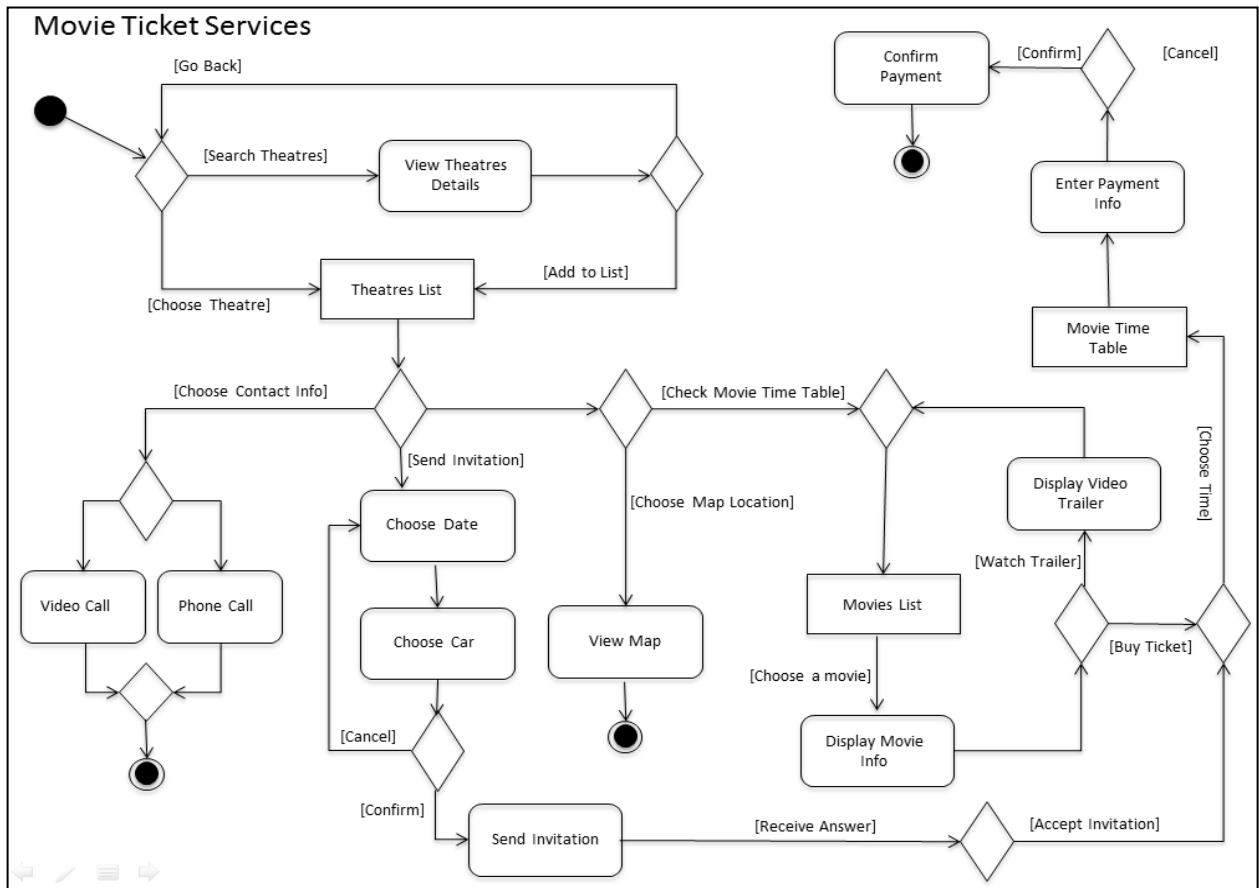


Figure 4-11: Movie Ticket Services Interaction Diagram

When choosing Movie Ticket Service, it is possible to search for a theatre and add it to the list or choose a theatre to do the following:

- Make a video call or phone call with the theatre contact info service
- Find the map location of the theatre
- Check the movie time table to see the movies schedule
- When choosing a movie, the user can watch the movie trailer, and buy the ticket
- Send Invitation by choosing the date and a car from the cars list then confirm sending
- Buy Ticket: Enter the required information to buy ticket and confirm payment

4.2 Physical Design

In this part we have to think about the required components and the screen's design. There are many different ways and levels to represent the prototype.

4.2.1 First Mock-up Prototype

A mock-up is one of the fastest ways to validate any interface design [51]. Mock-ups give the user a visual perception of the system concept and the flows between the screens. In addition, mock-ups help reduce the cost of software development. A mock-up is “a static rendering of a visual design” [51]. It is static because the user interaction with the mock-up interface differs from the interaction with the real system interface. A mock-up can be represented using different forms. It can be a handwritten sketch, or it can be made to look exactly like the real interface, by using a drawing application. We used Microsoft PowerPoint to create the first mock-up prototype. The goal of a mock-up prototype is to validate the design decision or concept [51]. When we designed the first prototype, there was one mode for all the users of the system and the main functions were:

- Local Multimedia
- Internet Access
- Emergency Services
- Info Sharing
- Touristic Services
- Navigation System
- Car Information

Design Description

- **Colors:** Since we want to use less than five colors and avoid using combinations of colors that cause confusion for the color blind, the interface consists of a combination between three colors: black, red and gray. The main color for the labels and of the text is white, so that it is clear and easily readable on the black background.

- **Controls:** We use the combination of pictures and labels to identify the system controls and to make them meaningful. In addition, the icons are big and at a suitable distance from each other to allow the user to distinguish them from one another.
- **Consistency:** The font size and the design of all the data are consistent. For example, all the lists have the same design, font, and structure.
- **Feedback:** When the users perform any task, they are provided with feedback to keep them informed about what is going on. The feedback is provided using sensory cues such as audio, gestures, haptics etc.
- **Notifications:** A warning message is provided if there is a system update or in case of emergency.
- **Icon Design:** Some images used to represent the icons are from Google images, others were designed by us.

After finishing the design of the first prototype, the next step is to test the usability and effectiveness of the proposed interface, as shown in the next section.

4.2.2 Usability Test

4.2.2.1 Executive Summary

The usability test took place in the Discovery lab. The participants performed the test in March 2012 and each participant performed all the tasks in 20-25 minutes. The objective of the test is to measure the usability of the interface and the functions of the first mock-up prototype. Moreover, the major goal of the test is to improve the software after reviewing the test findings. As a result of the test, we discovered some problems:

- The location of the “Weather Information” feature
- The comprehensibility of the “Save” function in “Search Restaurant”
- The location of emergency call in “Emergency Services”
- The use of one icon to represent two functions

This section proposes solutions after measuring the task completion rates, the response time, the participant ratings of each task, and the overall satisfaction ratings.

4.2.2.2 Methodology

The methodology is to evaluate the usability of each function by observing the participants' interaction with the system while they complete the required tasks, then analyzing the problems they faced during the test, in order to find suitable solutions.

4.2.2.3 Participants

Six users, in age between 23 and 30, participated in the usability test. There were four female and two male. They had the right to stop the test at any time, if they did not feel comfortable. The participants were honest and did their best to complete the tasks. Moreover, the participants answered the satisfaction questionnaire once they had completed the tasks.

4.2.2.4 Procedure

The usability test was recorded using a mobile video recorder. Each participant was given 21 tasks to perform. Each task tests the usability of the system interface design functions.

- Task 1: tests the usability of “Radio Station” functions.
- Task 2: tests the usability of “CD” functions.
- Task 3: tests the usability of “Digital Audio” functions.
- Task 4: tests the usability of “Photos” functions.
- Task 5: tests the usability of “DVD” functions.
- Task 6, 7, 8, and 9: test the usability of “Internet Access” functions.
- Task 10: tests the usability of “Weather Info” functions.
- Task 11: tests the usability of “Info Sharing” functions.
- Task 12: tests the usability of “Restaurant Services” functions.
- Task 13: tests the usability of “Cultural Events Services” functions.
- Task 14: tests the usability of “Movie Ticket Services” functions.
- Task 15 and 16: tests the usability of “Emergency Services” functions.

- Test 17 and 18: test the usability of “Car Info” functions.
- Test 19: tests the usability of “Navigation System” functions.
- Test 20: tests the usability of “My Schedule” functions.
- Test 21: tests the usability of “Social Summary” functions.

The users were asked to read the task scenarios out loud, and each task was written on a separate card. While the participants were performing the required tasks, their response time was measured. Once the users had finished the test, they were given a questionnaire to answer, to give their impression of the design and help us measure their satisfaction. The questionnaire used multiple choice questions and open-ended questions to verify:

- The learnability of the system functions
- The productivity of the user
- If the system meets the users expectations
- How easily the systems functions and terminologies are understood
- The attractiveness of the interface
- The complexity of the functions
- If the experience was frustrating
- What they disliked the most about the system
- What they liked the most about the system

The tasks given as well as the questionnaire are included in Appendix A, sections 2 and 3.

4.2.2.5 Findings

The results of the evaluation were found while observing the participants, but also after analyzing the problems, measuring the response time, counting the number of completed tasks, and verifying the time needed to complete each task.

4.2.2.5.1 Tasks’ Path

See Appendix A section 3.

4.2.2.5.2 Task Completion Rate

Table 3.2 shows the task completion rate for each participant.

Tasks	Total Rate
Task 1	100%
Task 2	100%
Task 3	100%
Task 4	100%
Task 5	100%
Task 6	100%
Task 7	100%
Task 8	100%
Task 9	100%
Task 10	0%
Task 11	100%
Task 12	100%
Task 13	100%
Task 14	100%
Task 15	100%
Task 16	100%
Task 17	100%
Task 18	100%
Task 19	100%
Task 20	100%
Task 21	100%

Table 4-2: Task Completion Rate

None of the participants could complete task 10 without help. In addition, participant 3 and participant 5 had some difficulty completing task 12. On the other hand, all participants completed the rest of the tasks without any help.

4.2.2.5.3 Task Completion Time

After reviewing the videos and calculating the required time to complete each task and subtask, we summarized the completion time in the following table:

Task#	Average	Standard Deviation
Task 1	27.94	17.34
Task 2	10.47	6.18
Task 3	11.08	6.62
Task 4	10.97	6.74
Task 5	12.39	7.58
Task 6	12.72	7.77
Task 7	19.17	12.11
Task 8	27.30	16.99
Task 9	13.72	8.59
Task 10	-	-
Task 11	50.56	31.95
Task 12	92.39	60.45
Task 13	20.27	16.85
Task 14	44.57	28.88
Task 15	8.04	4.83
Task 16	20.60	12.64
Task 17	13.22	8.03
Task 18	19.66	12.14
Task 19	21.08	13.31
Task 20	4.21	2.50
Task 21	3.73	2.05

Table 4-3: Task Completion Time

It is obvious that the participants performed the tasks in the same range of time, and that none of them could complete task 10.

4.2.2.5.4 Participant Rating of Each Task

The user's performance completing each task can be rated from 1(failure) to 5 (zero frustration), as follows:

- The user could not complete the task (failure) =1.
- The user completed the task, but it required much more effort/time than expected (High frustration) = 2.
- The user completed the task, but it required more effort/time than expected (Medium frustration) = 3.
- The user completed the task with only minor difficulties (Little frustration) = 4.
- The user completed the task without difficulty (zero frustration) = 5.

Tasks	Total rating of each task
Task 1	83%
Task 2	100%
Task 3	100%
Task 4	100%
Task 5	100%
Task 6	100%
Task 7	100%
Task 8	100%
Task 9	100%
Task 10	20%
Task 11	93%
Task 12	60%
Task 13	93%
Task 14	100%
Task 15	60%
Task 16	100%
Task 17	100%
Task 18	100%
Task 19	100%

Task 20	100%
Task 21	100%

Table 4-4: Participant Rating of Each Task

We can group the task performances into three groups, depending on the average rating (60%):

- Group 1: Above average > 60%
- Group 2: Average > 60% & <80%
- Group 3: Below average > 60%

As a result, each group contains the following tasks:

- Group 1: Tasks 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13, 14, 16, 17, 18, 19, 20, 21.
- Group 2: Tasks 12, 15.
- Group 3: Task 10.

The following table shows the problems faced by the participants while completing the tasks with a performance rate average or under the average:

Task	Problem
Task 10: test the usability of the “Weather Information” functions	The location of the “Weather Information” feature
Task 12: test the usability of the “Restaurant Services” functions	The comprehensibility of the “Save” function in “Search Restaurant”
Task 15: test the usability of the “Emergency Services” functions	The location of emergency call in “Emergency Services”

Table 4-5: Problems of the Tasks Under or Equal to the Average Rate

4.2.2.5.5 Satisfaction

After each participant finished the test, they were given a questionnaire to measure the usability of the application, from the user’s point of view. The questionnaire is included in Appendix A. The questionnaire consists of 17 questions; multiple choice and open-ended. These questions are:

1. *It is very easy to learn how to use the system.*

Two participants chose (Strongly agree), two participants chose (Agree), one participant chose (Neutral) and one chose (Disagree).

2. *The most interesting functions in the system is/are:*

The participants find Info Sharing, Touristic Services, and Car Info the most interesting functions.

3. *I like the sequences of operations.*

Three participants chose (Strongly agree), two participants chose (agree), and one participant chose (Neutral).

4. *The terminologies used are*

Five participants chose (Easy to understand) and one chose (Neutral).

5. *The method used for adding, editing, or deleting an object is*

All participants chose (Clear).

6. *The font size is*

All participants chose (Suitable).

7. *The font color is*

All participants chose (Clear).

8. *The pictures used are*

All participants chose (Meaningful).

9. *I like the combination of pictures and text in the system.*

Three participants chose (Strongly agree), and three participants chose (Agree).

10. The functions of the system are very

Five participants chose (Useful) and one chose (Important).

11. What is more suitable for you

All participants chose (The touch based screen).

12. As a driver, I would often

The most frequent answers, in order: use the navigation system, listen to music, check traffic info, and check my car's information.

13. As a passenger, I would often

The most frequent answers, in order: listen to music, watch movies, use info sharing, use touristic services, and use Internet access.

14. I was very comfortable when I used the system.

Four participants chose (Strongly agree), and two chose (Agree).

15. I would like to buy a car that has a similar system.

Four participants chose (Strongly agree), and two chose (Agree).

16. What did you like most about the system?

Some participants like the new features like info sharing and touristic services, and others like the design of the system.

17. What did you like the least?

All participants agree that the location of "Weather Info" should not be in News, but on the main page. One participant noticed that there is one icon that is used for two functions, which is confusing.

As a result of the questionnaire, we can conclude that there are two problems in the system's design that need to be taken into consideration:

- The location of the “Weather Info” feature
- The use of one icon to represent two functions

4.2.3 Problems and Solutions

Based on the analysis and survey in section 3.2.3.5, we found that 3 participations found that Task 15 is not straight forward while all the participants found that Task 10 is difficult to achieve. This is due to the fact that

1. The location of the “Weather Information” feature
2. The comprehensibility of the “Save” function in “Search Restaurant”
3. The location of emergency call in “Emergency Services”
4. The use of one icon to represent two functions

This section explains each problem in detail and categorizes it based on the severity of the problem and the broken heuristic; then suggests a possible solution for each one.

When measuring the severity of any problem, two things should be considered:

Problem Frequency:

The problem frequency is categorized into three types:

- High frequency: the user frequently encounters the problem.
- Moderate frequency: the user occasionally encounters the problem.
- Low frequency: the user rarely encounters the problem.

Problem Impact:

The impact the problem has on users, when they encounter it, could be one of the following:

- High impact: the problem affects the users' performance and prevents them from completing the task.
- Moderate impact: the user completes the task but the problem causes them difficulties in the process.

- Low impact: causes some minor difficulties that do not affect the completion of the task.

4.2.3.1 Problem Description

A. The Location of the “Weather Information” Feature

A.1 Description

During the usability test, the participants were asked to check the weather. None of the participants were able to find the location of the weather information feature without my help.

The following figure shows the task path which is: Main Menu > Internet Access > News > Weather Info.

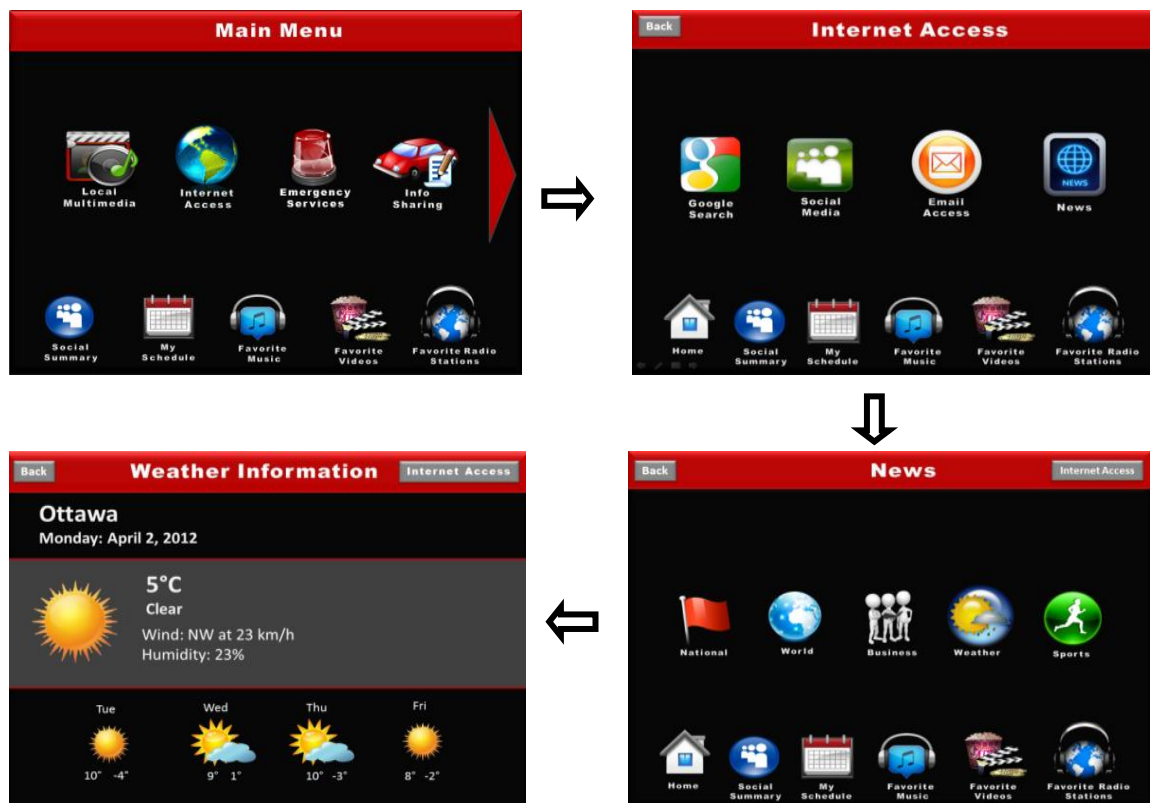


Figure 4-12: Task 10 Path

A.2 Severity

- **Frequency**

This problem is high frequency since users encountered this problem each time they tried to obtain a weather update.

- **Impact**

This problem high impact because, since the participants could not find the location of the tool, they could not complete the task.

A.3 Broken Heuristic

The broken heuristic is "Use simple and natural dialogue".

A.4 Proposed Solution

It would be useful to place the weather summary in the main page of the system, as seen below:



Figure 4-13: Location Solution

B. The Comprehensibility of the “Save” Function in “Search Restaurant”

B.1 Description

When the participants were asked to add one of the search results to the restaurant list, they chose the Add icon. Later, when they wanted to exit the screen, they had to select “Save”, which was an ambiguous sequence. Figure 3 helps visualize the problem.



Figure 4-14: Adding Search Result to the System List

B.2 Severity

- **Frequency**

This problem is low frequency since users encountered this problem only when they wanted to add the search result to the system list.

- **Impact**

This problem is low impact since it does not affect the completion of the task.

B.3 Broken Heuristic

The broken heuristic is "Provide clearly marked exits".

B.4 Proposed Solution

There are two possible solutions:

- Use the "Check List" icon instead of the "Plus" icon and then use "Add" instead of "Save".



Figure 4-15: Adding Search Results to the System Solution 1

- Change the “Save” icon to “Done”.



Figure 4-16: Adding Search Results to the System Solution 2

C. The Location of Emergency Call in “Emergency Services”

C.1 Description

The participants were asked to call in an emergency, and it took them a long time to find how they could do this. There are two functions that can be used:

- Call Fire and Rescue Services
- Send Code to Control Center

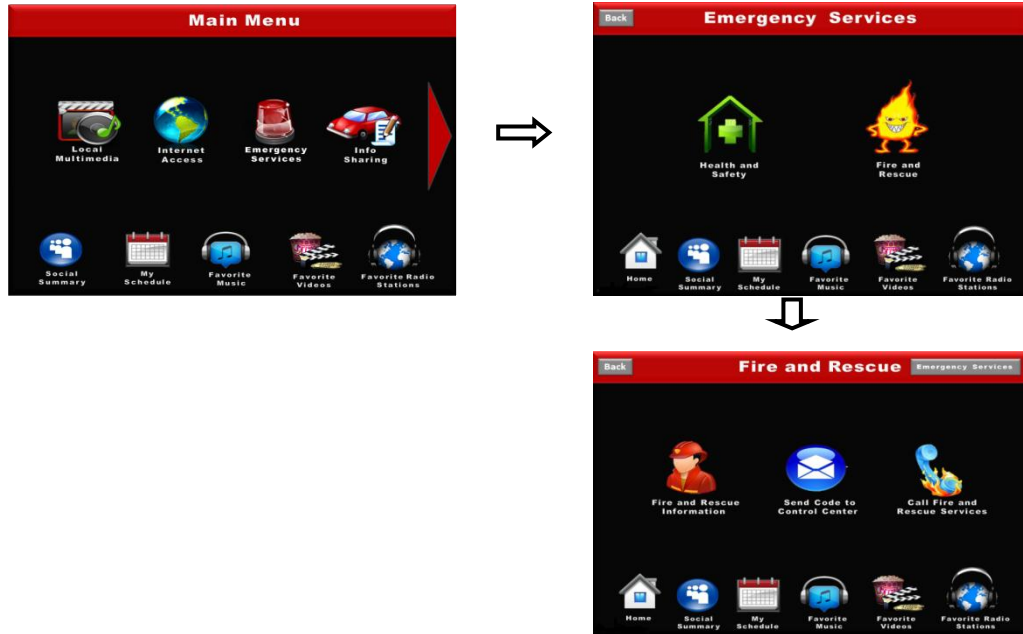


Figure 4-17: Call Emergency Location Problem

C.2 Severity

- **Frequency**

This problem is high frequency since users encountered it each time they simulated an emergency, and this affects the driver and passenger’s safety.

- **Impact**

This problem is of moderate impact since the user completes the task, but the problem causes them some difficulties as they do it.

C.3 Broken Heuristic

The broken heuristic is "Use simple and natural dialogue".

C.4 Proposed Solution

Add a “Call Emergency” icon in the main page of the system, as seen below:



Figure 4-18: Call Emergency Solution

D. The use of one icon to represent two functions

D.1 Description

There is one icon in the system that is used twice for different purposes: one to represent “Info Sharing” and the other to represent “Send Invitation”. See Figure 3.

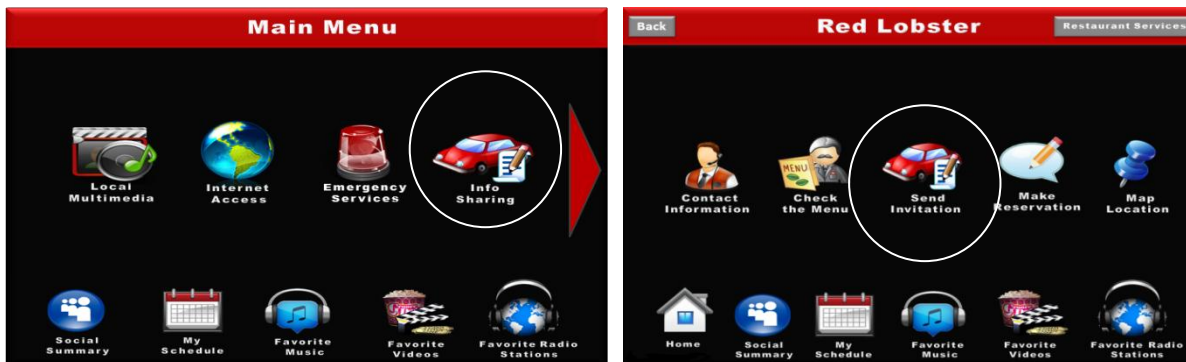


Figure 4-19: Using Same Icon for Different Functions

D.2 Severity

- **Frequency**

This problem is high frequency since users encountered it each time they used the “Info Sharing” or “Send Invitation” functions.

- **Impact**

This problem is low impact since the participants were able to complete the task without help, but they did complain about the icon being used twice.

D.3 Broken Heuristic

The broken heuristic is "Use simple and natural dialogue".

D.4 Proposed Solution

The proposed solution is to design a new icon for the "Info Sharing" function. This icon will look like:



Figure 4-20: New Info Sharing Icon

Given the satisfactory results for the first mock up testing, we decide to implement the first functional prototype of the system based on this design which was modified to solve the encountered issue.

Chapter 5

Implementation

5.1 Implementation Environment

To implement our proposed system, we used XCode 4.3, a software development environment that uses Objective C language as a programming language. We then used iPad as a real environment device, to test the system. Figure 4.12 illustrates the infotainment system’s architecture implementation.

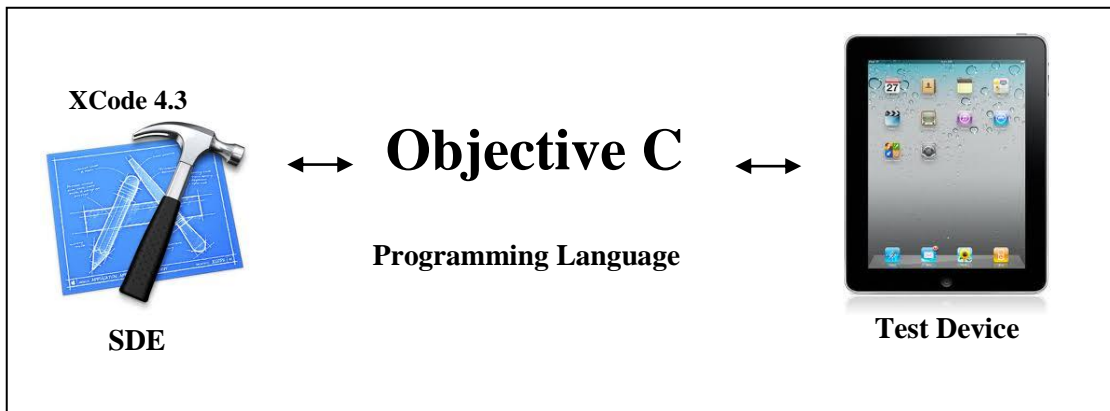


Figure 5-1: Infotainment System’s Architecture Implementation Tools

5.2 First Functional Prototype

This prototype is the implementation of the modified version of the first mock-up. While designing the user interface of the first functional prototype, we considered all of the problems and solutions that resulted from the first mock-up usability test. We used the standard iOS components in order to implement the different functions exposed in chapter 3. The following figures illustrate few examples in component usage the first functional prototype.

- The Main Menu interface: We will have a collection of four icons per page, representing the main functions. We all have few “hot shortcuts” icons that will always be displayed on the button.

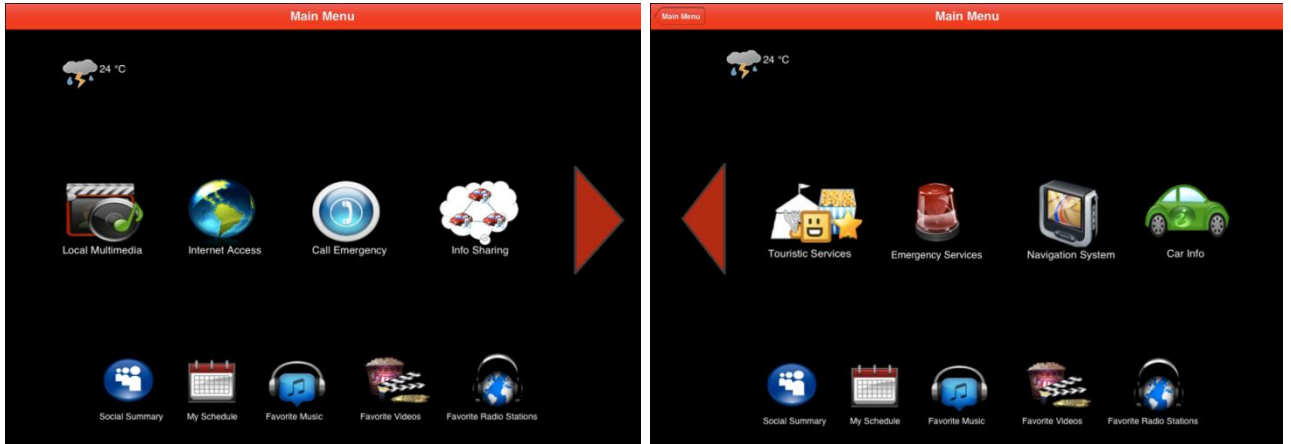


Figure 5-2: Main Menu of the System

- The list and search engine: We use the UI table view to represent the lists. Those lists will be ideally dynamic populated given the results returned by a database request.



Figure 5-3: List and Search Engine

- Audio Multimedia System: We used the AVFoundation framework to represent the audio file.



Figure 5-4: Audio Multimedia System

- Web Search: We adapt the Google search webpage as our web search engine.

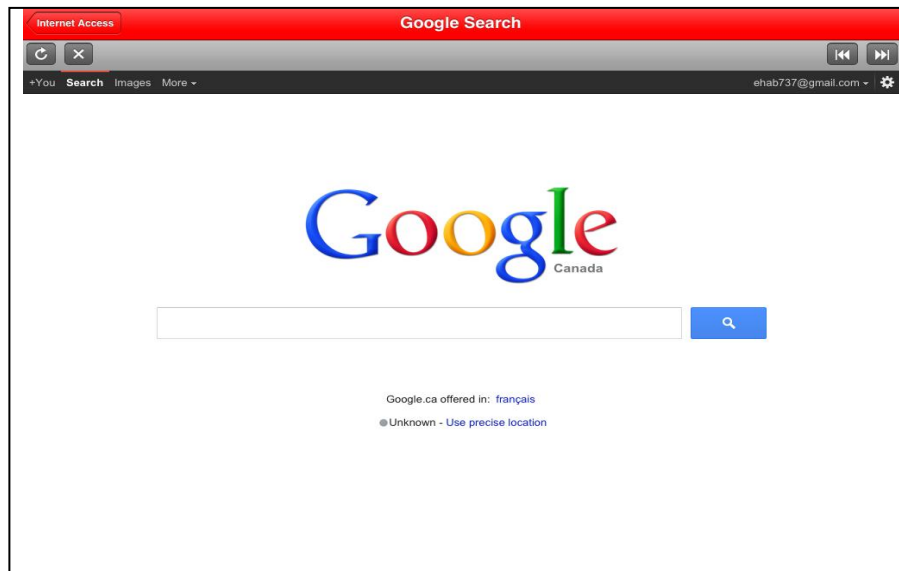


Figure 5-5: Web Page

- View Map: We also use UI Map view in order to display the locations and show routes.

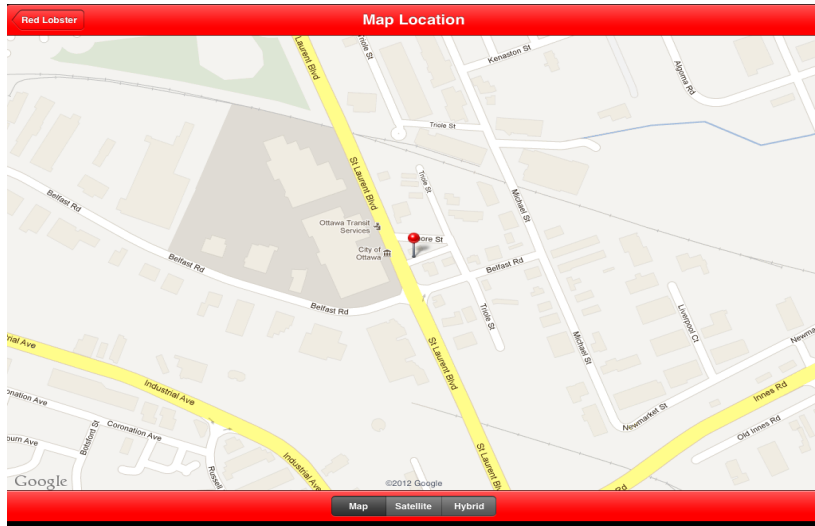


Figure 5-6: Web Page

- Text Entries: For all text entries we used the field (UI text field class) which is associated with the standard iOS keyboard.

Figure 5-7: Text Entries

- Drop Menu: We use UI Picker to represent the drop down menu and use the popover to display the picker when the user presses on the drop icon.

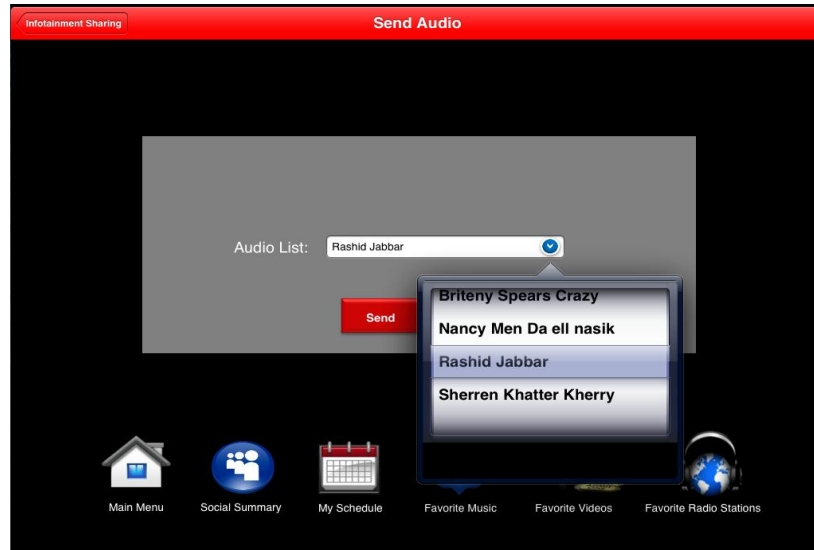


Figure 5-8: Drop Menu

- Dates: Whenever we need to choose the date, we can do it by using the date picker which use (UI Date Picker) class in XCode.

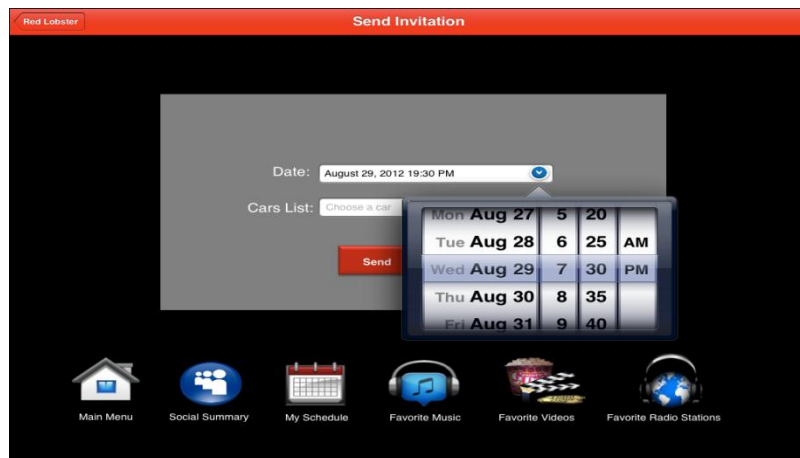


Figure 5-9: Date Picker

- Warning Message: All warning messages and feedback messages are displayed using the blue message box called UI Alert. In order to guarantee the user control, we always give him the possibility to cancel or dismiss...etc.



Figure 5-10: Warning Message

- Photos: Use the back camera or access the photo library to select photos.

5.2.1 Usability Test and Results

5.2.1.1 Executive Summary

In order to evaluate the validity of our implementation, we made a second usability test. The usability test took place in the Discovery lab. The participants performed the test in May 2012 and each participant performed all the tasks in 20-25 minutes. The objective of the test is to measure the usability of the interface and the functions of the first functional prototype. Moreover, the major goal of the test is to improve the software after reviewing the test findings. As a result of the test, we discovered some problems with the following aspects:

- Data entry
- Word "Dismiss"
- Need confirmation

There are also some new features that need to be added to the system:

- Allow a search from current location
- Limit the driver functions
- Add video chat to contact information
- When a warning message is received, provide an option for the user to decide to view it now or later

Solutions are proposed after evaluating the task completion rates, the response times, participant ratings of each task, and overall satisfaction ratings.

5.2.1.2 Methodology

The methodology is to evaluate the usability of each function by observing the participants' interaction with the system while they complete the required tasks, then analyzing the problems they faced during the test, in order to find suitable solutions.

5.2.1.3 Participants

Five users participated in the usability test, in age between 20 and 35, four female and one male. They had the right to stop the test at any time, if they did not feel comfortable. The participants were honest and did their best to complete the tasks. Moreover, the participants answered the satisfaction questionnaire once they had completed the tasks

5.2.1.4 Procedure

The usability test was recorded using a mobile video recorder. Each participant was given the same tasks that were given in the first mock-up, but in a different order. To analyse the tasks, we use the same task order as in the first mock-up, to prevent confusion. Review section 4.2.2.4 in Chapter 4.

The users were asked to read the task scenarios out loud, and each task was written on a separate card. While the participants were performing the required tasks, their response time was measured. Once the users had finished the test, they were given the same questionnaire

used in the first mock-up to make sure the proposed solutions were effective, to collect more results, and to determine if there were any other problems with the design.

5.2.1.5 Findings

The results of the evaluation were found while observing the participants, but also after analyzing the problems, measuring the response time, counting the number of completed tasks, and verifying the time needed to complete each task.

5.2.1.5.1 Tasks' Path

The tasks' paths are the same as in section 3.2.3.5 in Chapter 3 except the following tasks:

- Task 10: Main Menu > Weather Info.
- Task 12: Main Menu > Touristic Services > Restaurant Services > Search Restaurant > Red Lobster > Add to the List.
- Task 15: Main Menu > Call Emergency.

5.2.1.5.2 Tasks Completion Rate

All participants completed all the tasks successfully, without any help.

5.2.1.5.3 Task Completion Time

After reviewing the videos and calculating the required time to complete each task and subtask, we summarized the completion time in the following table:

Task#	Average	Standard Deviation
Task 1	22.64	7.50
Task 2	8.33	3.03
Task 3	8.85	3.15
Task 4	8.85	3.00
Task 5	9.99	3.40
Task 6	10.24	3.50
Task 7	15.64	5.00
Task 8	22.15	7.29
Task 9	11.16	3.63
Task 10	-	-
Task 11	41.25	13.16

Task 12	76.42	22.59
Task 13	18.56	2.42
Task 14	36.72	11.09
Task 15	6.43	2.27
Task 16	16.62	5.63
Task 17	10.62	3.67
Task 18	15.90	5.32
Task 19	17.20	5.50
Task 20	3.36	1.21
Task 21	2.89	1.19

Table 5-1: Task Completion Time

It is obvious that the participants performed the tasks in the same range of time. No one need more time than the others to complete any tasks in particular.

5.2.1.5.4 Participant Rating of Each Task

The user's performance completing each task can be rated from 1(failure) to 5 (zero frustration) as follows:

- The user could not complete the task (failure) =1.
- The user completed the task without difficulty (zero frustration) = 5.

All the tasks rates are equal to 100% except task 11 it take 60% because the participants spent more time in typing and it depend on the typing skills, and task 12 equal 88%.which is above the average.

The following table shows the problems faced by the participants while completing the tasks with a performance rate equal to or under the average:

Task	Problem
Task 11: test the usability of the "Info Sharing" functions	Typing mistakes while entering data

Table 5-2: The Problem with an Average Rate

5.2.1.5.5 Satisfaction

After each participant finished the test, they were given the same questionnaire as in the first mock-up usability test, to measure the usability of the implemented application, from the users' point of view. The participants' answers on the questionnaire are the following:

1. *It is very easy to learn how to use the system.*

Two participants chose (Strongly agree), two participants chose (Agree), and one participant chose (Neutral).

2. *The most interesting functions in the system is/are:*

The participants find that Info Sharing, Touristic Services, and Car Info are the most interesting functions.

3. *I like the sequences of operations.*

Three participants chose (Strongly agree), and two participants chose (agree).

4. *The terminologies used are*

All participants chose (Easy to understand).

5. *The method used for adding, editing, or deleting an object is*

All participants chose (Clear).

6. *The font size is*

All participants chose (Suitable).

7. *The font color is*

All participants chose (Clear).

8. *The pictures used are*

All participants chose (Meaningful).

9. *I like the combination of pictures and text in the system.*

Three participants chose (Strongly agree), and two participants chose (Agree).

10. *The functions of the system are very*

Four participants chose (Useful) and one chose (Important).

11. *What is more suitable for you*

All participants chose (The touch based screen).

12. *As a driver, I would often*

The most frequent answers, in order: use the navigation system, listen to music, check my car's information.

13. *As a passenger, I would often*

The most frequent answers, in order: listen to music, watch movies, use info sharing, use touristic services, use Internet Access.

14. *I was very comfortable when I used the system.*

Four participants chose (Strongly agree), and one chose (Agree).

15. *I would like to buy a car that has a similar system.*

Four participants chose (Strongly agree), and one chose (Agree).

16. *What did you like most about the system?*

Three participants like the new features like info sharing and touristic services, and the others like the design of the system.

17. What did you like the least?

- Some participants do not like entering data; they prefer multiple choices.
- Two participants do not like the word “Dismiss” in alert messages.
- Three participants do not like to do any operations without being asked for a confirmation.

In the comment area, the participants suggested adding the following features:

- Allow searching for the closest restaurants from current location
- Do not allow the driver the option of watching a movie, and limit operations that need data entry, to increase safety.
- Make video chat one of the contact information options
- When a warning message is received, provide an option for the user to decide to view it now or later.

5.2.2 Problems and Solutions

Based on the analysis and survey in section 4.3.1.5, we found that most of the subject found made typing mistakes while typing the required data to complete Task 11 ”Add a car to Cars List” which caused more time to perform the task. In addition, some of them did not like word “Dismiss” and others ask for confirmation while performing Task 12. As a result, we need to:

- Limit data entry
- Change the word “Dismiss”
- Ask for confirmation

In addition, we want to add the following ideas:

- Allow searching from current location
- Limit the driver functions
- Add video chat to contact information
- Allow User to View Warning Messages at a Later Time

The next section explains each problem in detail and categorizes it based on severity of the problem and the broken heuristic; then suggests a possible solution for each one.

5.2.2.1 Problem Description

A. Data Entry

A.1 Description

During the usability test, the participants were asked to add a car to “Cars List” and they had to enter the car name and number. While the participants entered the car name and number they made a number of typing mistakes and that cost them more time.

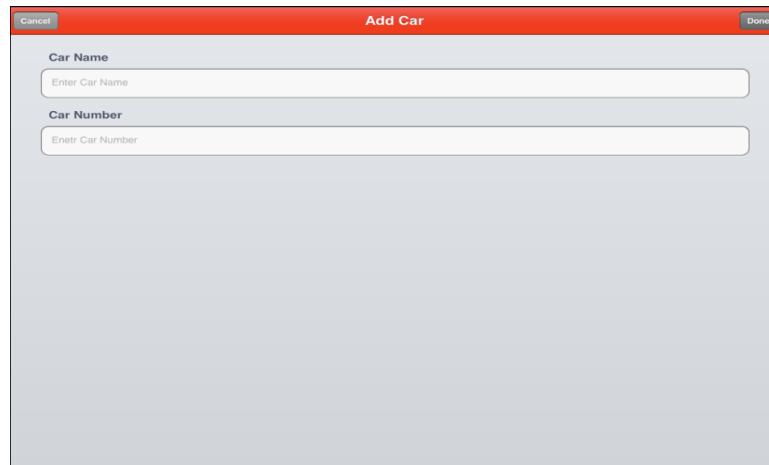


Figure 5-11: Data Entry

A.2 Severity

- **Frequency**

This problem is of moderate frequency since users encountered this problem each time they entered data in a text field.

- **Impact**

This problem is low impact since it causes some minor mistakes that do not affect the task completion.

A.3 Broken Heuristic

The broken heuristic is "Use simple and natural dialogue".

A.4 Proposed Solution

Allow the user to search for a car in the network and add it after reviewing its details, then ask the acceptance of the other car. The path of “Task 11” will be the following:

Main Menu > Info Sharing > Search Cars > “Nadeen’s Car” > View Details > Add to the List > Send Request Confirmation > Yes.



Figure 5-12: Problem 1 Solution

B. Word “Dismiss”

B.1 Description

During the usability test, the participants were asked to make a reservation in a restaurant and when they pressed “Confirm”, a confirmation message appeared. They had to press “Dismiss” to close the message. See Figure 4.24.



Figure 5-13: Problem 2

B.2 Severity

- **Frequency**

This problem is of moderate frequency since users encountered this problem each time a confirmation message appeared.

- **Impact**

This problem has no impact.

B.3 Broken Heuristic

The broken heuristic is "Use simple and natural dialogue".

B.4 Proposed Solution

Change the word “Dismiss” since the participants prefer the word “OK”, as they suggested in the usability questionnaire.

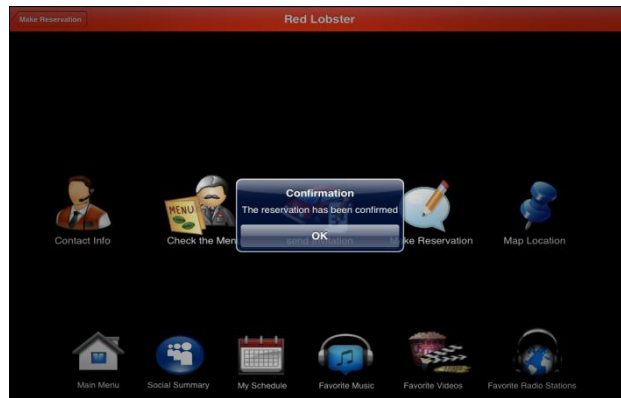


Figure 5-14: Problem 2 Solution

C. Need Confirmation

D. C.1 Description

When the participants wanted to send a video file to another car, they preferred to be asked for a confirmation before sending.

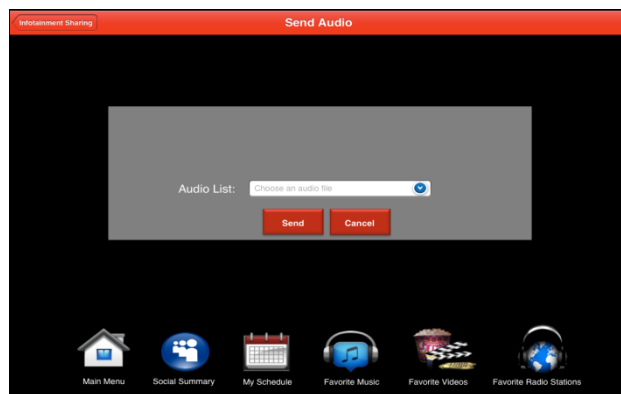


Figure 5-15: Problem 3

C.2 Severity

- **Frequency**

This problem is of moderate frequency since users encountered this problem each time they sent infotainment files to another car.

- **Impact**

The problem is low impact since it causes some minor mistakes that do not affect the task completion.

C.3 Broken Heuristic

The broken heuristic is "Prevent Errors".

C.4 Proposed Solution

When the user presses the “send” button, a confirmation message will appear.



Figure 5-16: Problem 3 Solution

Below we have listed a suitable solution for each idea that was suggested:

a. Allow searching from current location

The suitable solution

When the user wants to search for a medical center, restaurant, cultural event, or theater, there are two types of searches: search from current location, and view all, as seen in the following:

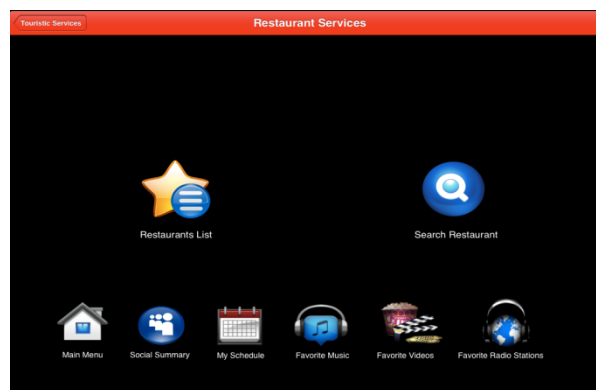


Figure 5-17: Search by Current Location

b. Limit Driver Functions

The suitable solution

Divide the user interface into three modes:

- Driver Mode: includes all the functions that are needed for the task of driving, and aim to increase driver safety and decrease driver distraction.



Figure 5-18: Driver Mode

- Full Mode: passengers above 10 years old and the driver, when the car is in Park, can use this mode, which includes all the system functions.

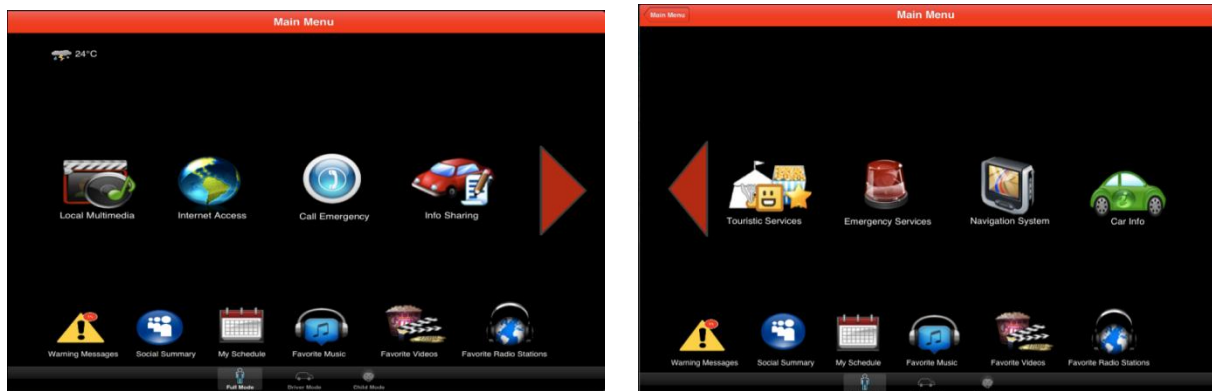


Figure 5-19: Full Mode

- Child Mode: passengers 10 years old or less can use this mode.



Figure 5-20: Child Mode

c. Add Video Chat to Contact Information

The suitable solution

Add a “Video Chat” button to contact information, to allow a video chat with the desired person or location, as seen below:

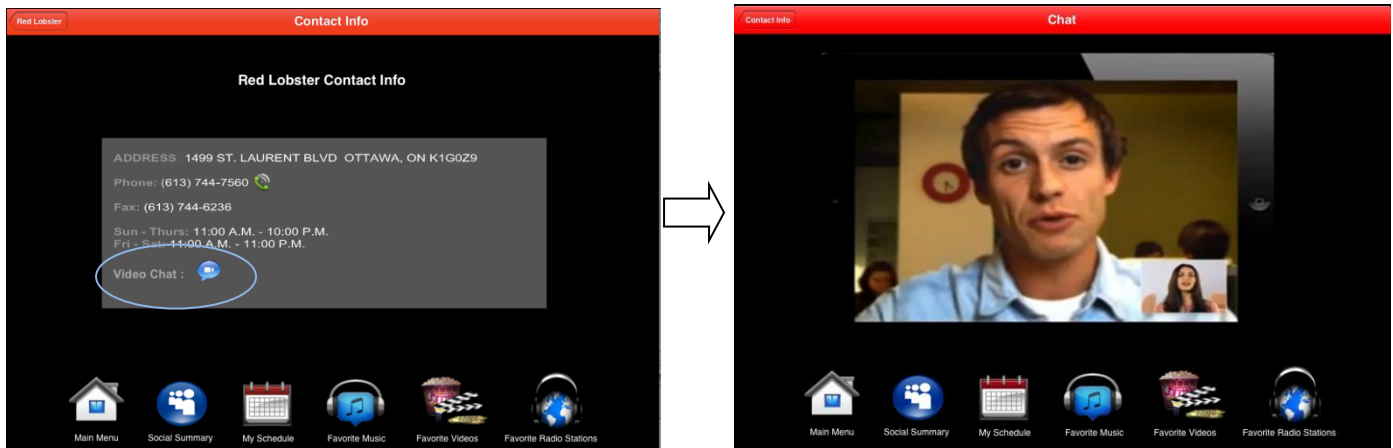


Figure 5-21: Add Video Chat to Contact Info

d. Allow User to View Warning Messages at a Later Time

The suitable solution

Add to all warning messages a button called “Decide Later”. When the user presses this button, the message will automatically be saved in a function called “Warning Messages” that can be accessed from each screen.

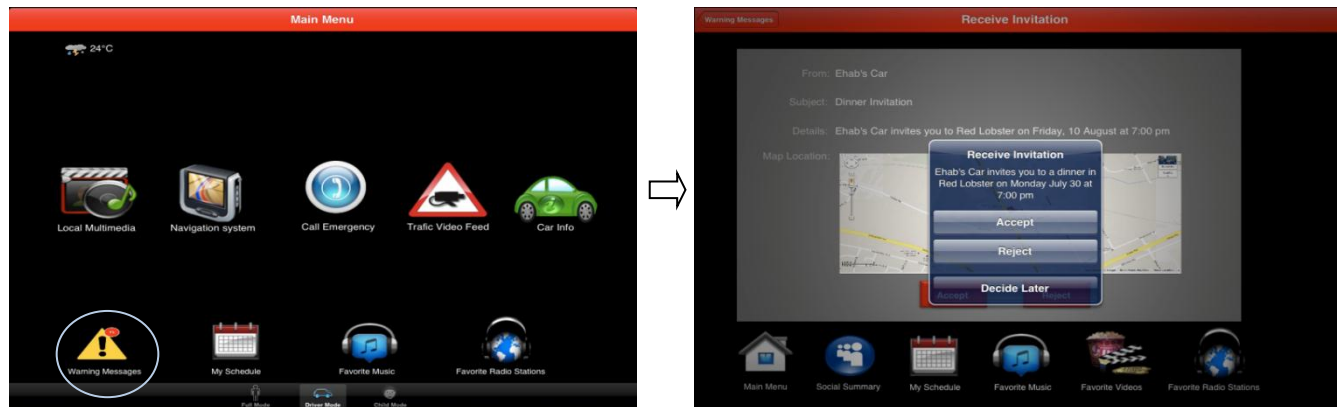


Figure 5-22: Warning Messages

5.3 Second Functional Prototype

After solving the problems from the first functional prototype and adding the proposed ideas, the main interface of the system will be the following:

- Full mode:



Figure 5-23: Full Mode

- Driver Mode:



Figure 5-24: Driver Mode

- Child Mode:



Figure 5-25: Child Mode

Each main screen consists of three areas:

- The Mode functions: includes the functions that belong to a particular mode and exist in the main interface of that mode.
- Short Cut Functions: includes the functions that remain in all screens of a mode.
- System Modes Tab: includes the three modes of the system: driver, child, and full.

Figure 4.29 shows the three parts of the system interface.



Figure 5-26: Three Parts of the System Interface

5.3.1 Usability Test and Results

5.3.1.1 Executive Summary

The usability test took place in the Discovery lab. The participants performed the test in September, 2012 and were divided into three groups (Driver, Passenger, and Child). Each group performed its own tasks in 5-7 minutes. The objective of the test is to measure the usability of the system interface and the functions of each mode.

The usability test measures the quantitative data (task timing) and the qualitative data (user satisfaction). As a result of the test, we discovered some problems:

- The name of “Emergency Services”
- The icon and the name of “Warning Messages”

Solutions are proposed after measuring the task completion rates, the response times, participant ratings of each task, and overall satisfaction ratings. At the end, we analyzed the findings and came up with the usability test results.

5.3.1.2 Methodology

While the users were performing the tasks, the required time was measured for each task. Then, a questionnaire was given to each participant to get the participant's opinion about the system's design and its features. The next step was to measure and analyze the mean of the time, and the overall ratings. At the end, we compiled the results, in order to reach our final conclusion.

5.3.1.3 Participants

Fifteen users participated in the usability test, in age between 5 and 35 years old. The first group (Driver Mode Group) consisted of six participants, two female and four men. The second group (Full Mode Group) consisted of six participants, three female and two male. The last group is the Child Mode Group; three boys participated in this group. The participants had the right to stop the test at any time, if they did not feel comfortable. The participants were honest and did their best to complete the tasks. Moreover, the participants answered the satisfaction questionnaire once they had completed the tasks.

5.3.1.4 Procedure

The usability test was recorded using a mobile video recorder. The users were divided into three groups: driver mode group, full mode group, and child mode group. The driver and full mode groups consisted of six participants each, whereas the child mode group consisted of three participants. The driver group was asked to perform five tasks. The full mode group was given thirteen tasks to perform, and the child mode group performed four tasks. The users were asked to read the task scenarios out loud, and each task was written on a separate card. While the participants were performing the required tasks, their response time was measured. Each task tests the usability of the functions in the different modes.

Once the users had finished the test, they were given a questionnaire to answer, to give their impression of the design and help us measure their satisfaction. The questionnaire uses the "Likert Scale" starting from strongly disagree, which is equal to 1, to strongly agree, which is equal to 5, and it verifies:

- The learnability of the system
- The productivity of the user
- If the system meets the users expectations
- How easily the systems functions and terminologies are understood
- The attractiveness of the interface
- The complexity of the functions
- If the experience was frustrating
- What they liked the most about the system

The tasks given and the questionnaire are included in Appendix A sections 4 and 6. The questionnaire was given to make sure the proposed solutions to the first functional prototype were effective, to collect more results, and to determine if there are any other problems with the design.

5.3.1.5 Findings

The results of the evaluation were found while observing the participants, but also after analyzing the problems, measuring the response times, counting the number of completed tasks, and verifying the time needed to complete each task.

5.3.1.5.1 Tasks' Path

Appendix A section 5 includes all the second functional prototype tasks' paths.

5.3.1.5.2 Task Completion Rate

Table 4.5 shows the task completion rate for each participant.

Driver Mode Group	
Tasks	Total Rate
Task 1	100%

Task 2	100%
Task 3	100%
Task 4	100%
Task 5	100%
Full Mode Group	
Tasks	Total Rate
Task 1	100%
Task 2	100%
Task 3	100%
Task 4	100%
Task 5	100%
Task 6	100%
Task 7	100%
Task 8	100%
Task 9	100%
Task 10	100%
Task 11	100%
Task 12	100%
Task 13	100%
Child Mode Group	
Tasks	Total Rate
Task 1	100%
Task 2	100%
Task 3	100%
Task 4	100%

Table 5-3: Task Completion Rate

All participants completed all the tasks successfully and mostly without any help. The only exceptions are Task 7 and Task 13 of the full mode, where some participants needed help to complete the tasks.

4.4.1.5.3 Task Completion Time

After reviewing the videos and calculating the required time to complete each task and subtask, we summarized the completion time in the following table:

Driver Mode Group		
Task#	Average	Standard Deviation
Task 1	30	11.56
Task 2	40	17.54
Task 3	4	1.56
Task 4	44	19.51
Task 5	7	2.85
Full Mode Group		
Task#	Average	Standard Deviation
Task 1	14	5.97
Task 2	15	5.95
Task 3	18	7.61
Task 4	12	5.05
Task 5	14	5.97
Task 6	57	24.46
Task 7	18	7.92
Task 8	62	26.78

Task 9	16	6.86
Task 10	33	13.85
Task 11	4	1.75
Task 12	4	1.66
Task 13	13	5.57
Child Mode Group		
Task#	Average	Standard Deviation
Task 1	16	8.47
Task 2	12	6.90
Task 3	26	14.43
Task 4	24	13.82

Table 5-4: Task Completion Time

It is obvious that the participants performed the tasks in the same range of time.

The following flowcharts demonstrate the statistical analysis for the average time of task completion.

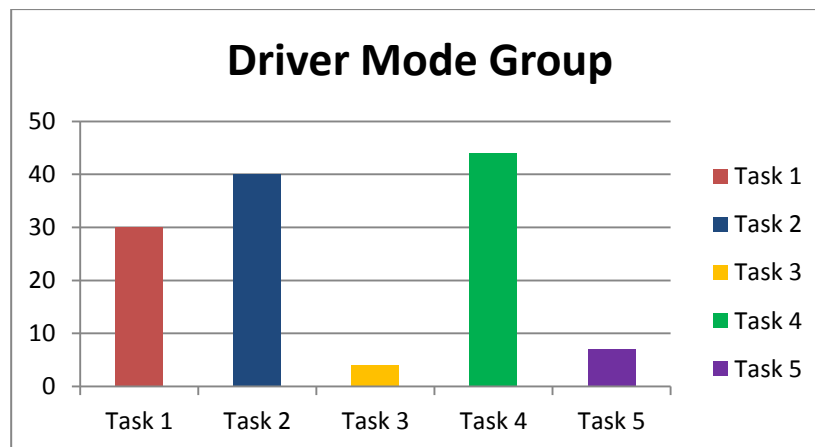


Figure 5-27: Driver Mode Group Completion Time Average

Of all their tasks, it took the participants of the driver mode group the most time to complete Task 4, and the least time to complete Task 3 but that does not mean the participants faced some difficulties in performing Task 4 but because it consisted of three parts to be performed.

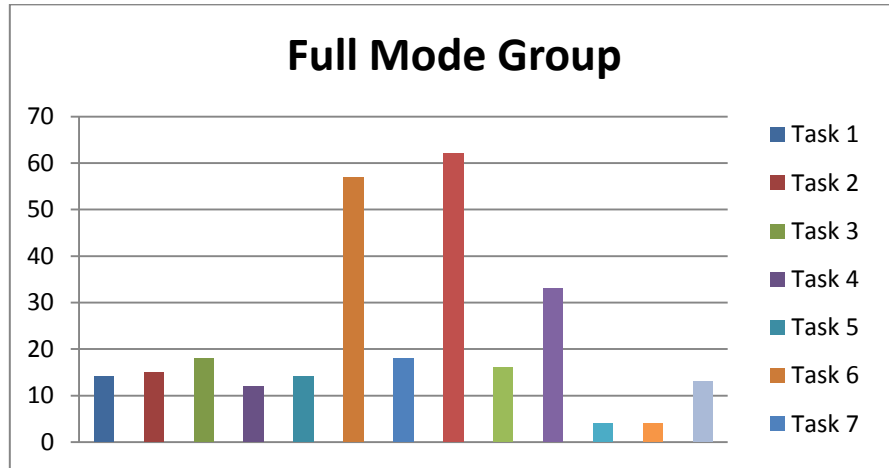


Figure 5-28: Full Mode Group Completion Time Average

The participants of the full mode group spent a lot of time completing Task 8 and Task 6 because these tasks composed of subtasks that required some time to be completed. On the other hand, Task 11 and Task 12 were completed in a short time. The other tasks were completed in the same range of time. In addition, the participants spent more time than it was expected to perform Task 7 and 13 because the name and the image of the used terminologies are not straight forward.

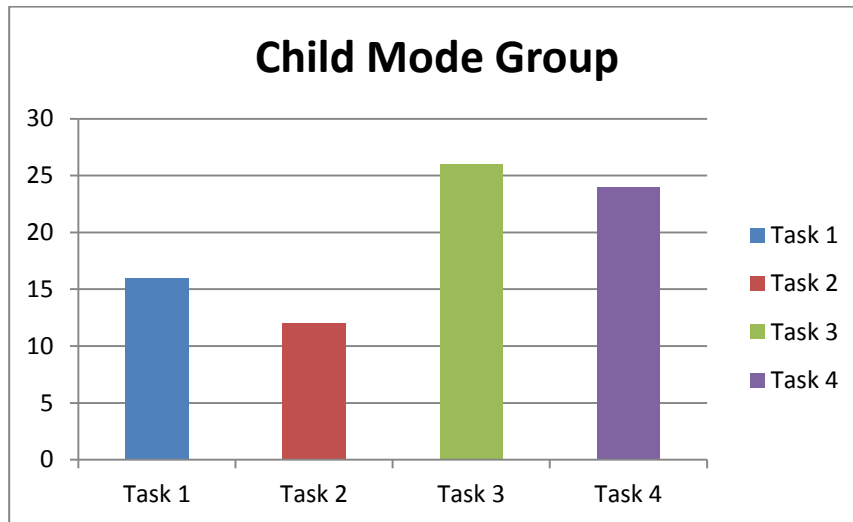


Figure 5-29: Full Mode Group Completion Time Average

The participants of the child mode group completed Task 3 and Task 4 in an average time of 20 to 27 sec, whereas Task 1 and Task 2 were completed in an average time of 12 to 16 sec.

5.3.1.5.4 Participant Rating of Each Task

The user's performance in completing each task scales from 1(failure) to 5 (zero frustration). The tasks of the diver and child mode groups were completed without any frustration where Task 7, and Task 13 were required more time than expected.

We can group the task performances into three groups, depending on the average rating (60%):

- Group 1: > 60%
- Group 2: < 60% & <80%
- Group 3: < 60%

As a result, each group contains the following tasks:

- Group 1 (above 60%):
 - In Driver Mode: Tasks 1, 2, 3, 4, 5.

- In Full Mode: Tasks 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12.
- In Child Mode: Tasks 1, 2, 3, 4.
- Group 2: (equal to 60%): No tasks.
- Group 3: (under 60%):
 - In Full Mode: Tasks 7, 13.

The following table shows the problems faced by the participants in the Full Mode group while completing the tasks with a performance rate under the average:

Task	Problem
Task 7: test the usability of “Emergency Services” functions.	The name of “Emergency Services” is not related to its contents.
Task 13: test the usability of “Warning Messages” function.	The name of “Warning Messages” is related to only some of its contents.

Table 5-5: Problems under the Average Rate

4.3.1.5.5 Satisfaction

After each participant finished the test, they were given a questionnaire to measure the usability of the implemented application, from the users’ point of view. The questionnaire uses the “Likert Scale” starting from strongly disagree, which is equal to 1, to strongly agree, which is equal to 5. It contains 15 questions that measure the following aspects:

- a. The learnability of the system.
- b. The efficiency of the interface design
- c. The usefulness of the system functions
- d. The interest in the system
- e. The most interesting function in the system

The questions are grouped according to the previous aspects. The following table summarizes the satisfaction rate of the participants:

	Aspect a	Aspect b	Aspect c	Aspect d
Average Rate	4.6	4.2	4.5	4.6

Table 5-6: Rate of Satisfaction

The average rates of all the questions are above 3. As a result, all the participants like the system and most of them find the system efficient, easy to learn and useful. See Figure 4.41.

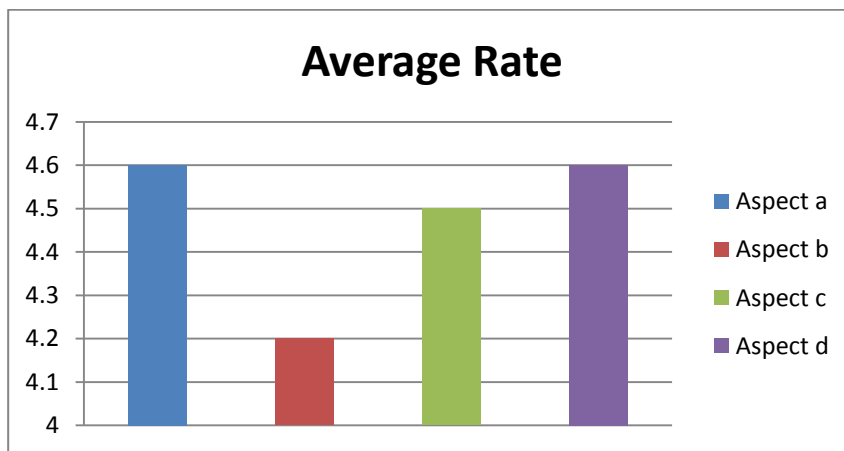


Figure 5-30: Satisfaction Average Rate

From the previous chart we can see that the participants' average rate of efficiency satisfaction is the lowest, because the participants of the full mode group found that the names and images of two icons were not efficient.

In addition, when we asked the participants in each group which is the function they liked the most while performing the tasks, the results were the following:

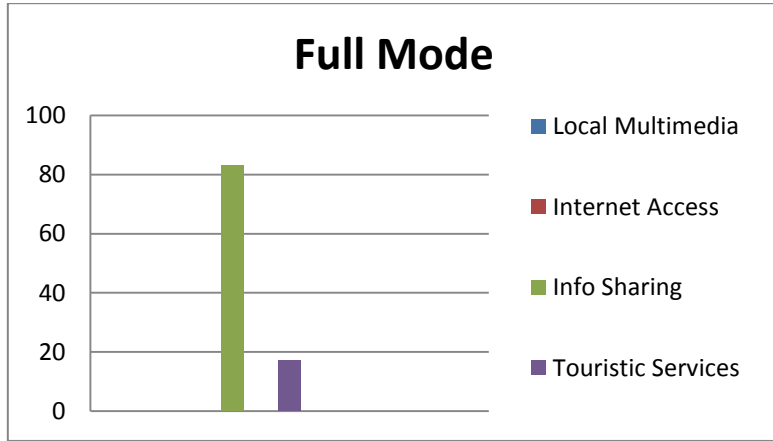


Figure 5-31: Full Mode Favourite Function

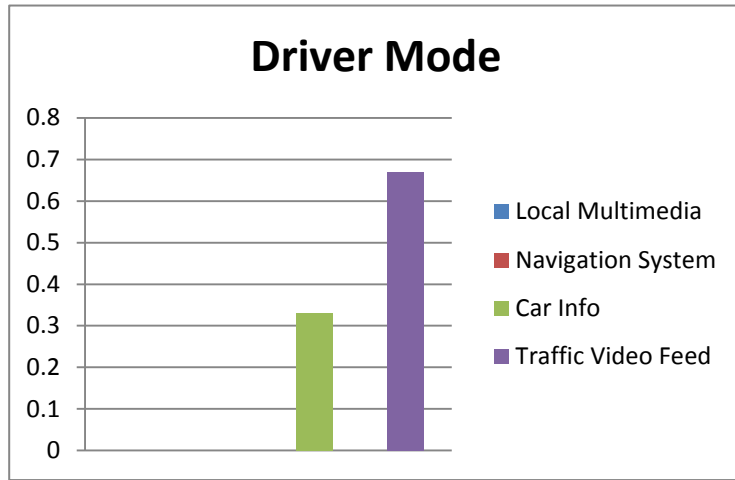


Figure 5-32: Driver Mode Favourite Function

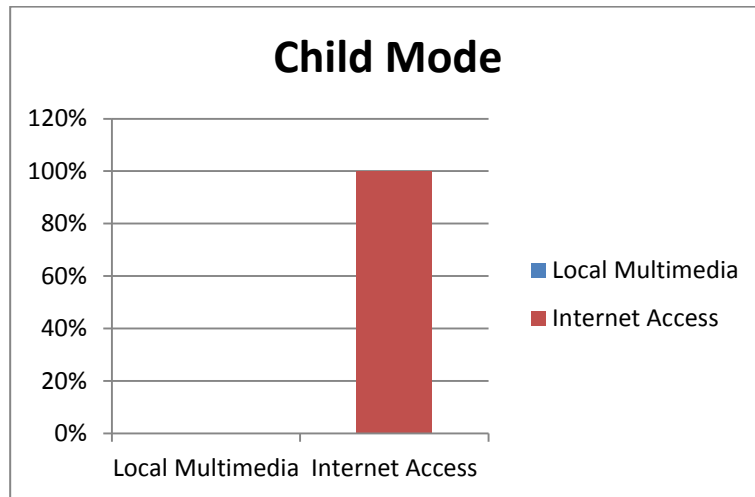


Figure5-33: Child Mode Favourite Function

From the previous flowcharts, we can see that: in the Full Mode group, about 82% of the participants find Info Sharing to be the most useful feature, and 18% like Touristic Services the most. In the Driver Mode group, 68% of the participants like the Traffic Video Feed the most, and 32% prefer Car Info. For the young participants, all of them like Internet Access the most.

5.3.2 Problems and Solutions

5.3.2.1 Problem Description

A. The Name and the Icon of “Emergency Services”

A.1 Description

During the usability test, the participants were asked to make an appointment at the Ottawa hospital, but they were confused and did not know that this function was included under “Emergency Services”.

A.2 Severity

- **Frequency**

This problem is high frequency since users encountered this problem each time they wanted to use the “Emergency Services” feature.

- **Impact**

This problem is high impact since it affects the completion of the task.

A.3 Broken Heuristic

The broken heuristic is "Use simple and natural dialogue".

A.4 Proposed Solution

We can change the name and the icon to the following:

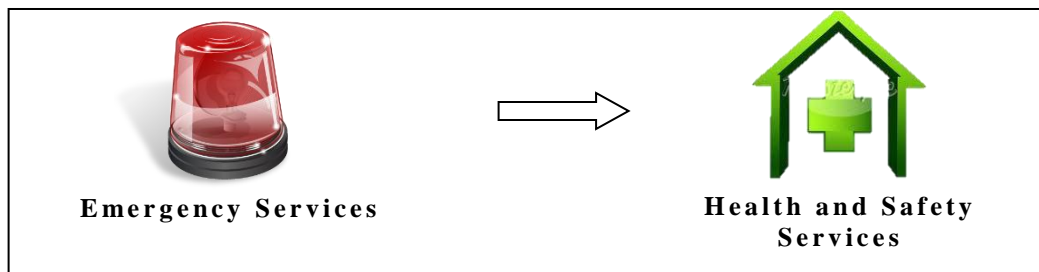


Figure 5-34: Change “Emergency Services” to “Health and Safety Services”

B. The Name and the Icon of “Warning Messages”

B.1 Description

During the usability test, the participants were asked to review the message received from another car. They were confused and did not know that this task is included under “Warning Messages”.

B.2 Severity

- **Frequency**

This problem is high frequency since users encountered this problem each time they wanted to use the “Warning Messages” feature.

- **Impact**

This is a high impact problem since it affects the completion of the task.

B.3 Broken Heuristic

The broken heuristic is "Use simple and natural dialogue".

B.4 Proposed Solution

In Full Mode, we can change the name and the icon to the following:

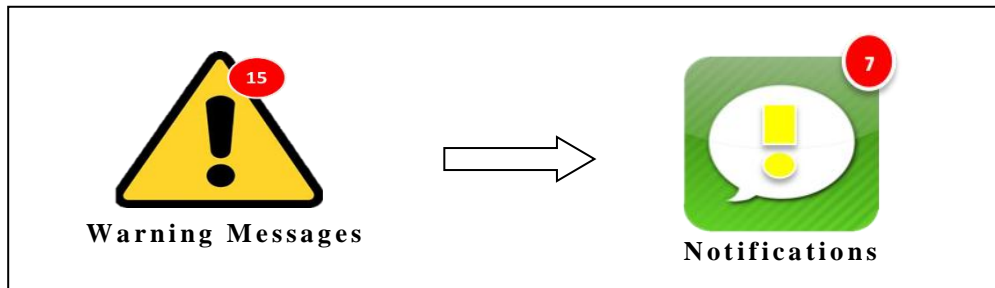


Figure 5-35: Change “Warning Messages” to “Notifications”

We stop at this level of testing and our final interface solves the problems that surfaced in the second functional prototype. The final portal design of our proposed system of three modes is shown in the following figures.

- Full Mode:



Figure 5-36: Final Full Mode Interface

- Driver Mode:



Figure 5-37: Final Driver Mode Interface

- Child Mode:



Figure 5-38: Final Child Mode Interface

Chapter 6

Conclusion and Future Work

Today, cars are not only a transportation media but a multifunctional living space as well. A consumer nowadays wants to access to the relevant information at any time of the day. In particular, car users (driver and passengers) are expecting more efficient infotainment services to be offered to them during their trips. This goal can be effectively met by taking advantage of the community paradigm created through a VANET. However the increasing number of available features should improve the users travelling experience without compromising their safety. Therefore, our proposed system serves different users of the infotainment system by providing three modes to satisfy the driver, the passengers and also the young passengers. We reviewed some related works about the infotainment guidelines to have a good knowledge to start designing the interface of our proposed system. In addition, we studied some luxury cars infotainment systems by reviewing the features and the used technologies in their systems. Through combining some of these systems features and coming up with some new ideas, we build a new system that has the main functions of the traditional infotainment system beside some new features such as info sharing, Internet Access and Touristic Services.

In order to build the interface of the proposed system, we started with collecting the needed information to know what people wish to have about their future in car infotainment system, then we gather all the information to have the main functions of the system and we applied three different tests to measure the usability of the system interface and functions. From each test we resulted in different problems and proposed different solutions, and then we tested the proposed solution in the next test to conduct more usability results and measure the usefulness of the proposed solutions. Finally, we stopped at the test results of the second functional prototype and after making the required changes.

Based on the analysis and survey of the second functional prototype, we found that 82% of the participants in the Full Mode group find Info Sharing is the most useful feature, and 18% like Touristic Services the most whereas about 68% of the subjects in Driver Mode group like the Traffic Video Feed the most, and 32% prefer Car Info. For the young participants, they like Internet Access the most.

However, our study opens the door for some interesting future work. First, we want to implement the using of different sensory cues for interaction. For example, apply voice warning, haptic feedback, and gestures especially for driver mode because these features reduce the driver distraction, and increase safety. In addition, we want to make the interface more dynamic by constructing the data bases such as, Audio List, Video List, Cars List, Restaurants List, Cultural Events, Theatres List and Medical Center data bases. Moreover, we want to add “Settings” Feature to the system to be more efficient. For example, we want to allow the driver to control the other modes from “Setting” Feature, like making the child mode mirror for the passenger mode and so on. In addition, allow dynamic interface; the user can change the location of the icons and control the interface. Finally, improve the time to complete few tasks especially for the driver to prevent distraction through redesigning the interface and the paths of the some process.

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Appendix A

A.1 Collection Questionnaire:

Please answer the following questions:

1. When you are driving, what do you like to do besides drive?

2. As a passenger in a car, what do you like to do?

3. If you have an infotainment system in your car with the following features (music, photos... etc.), which is the most important one for you?

4. When you are driving and using the infotainment system, what could distract you?

5. What do you do if you are at risk while driving?

6. When in a car, how often do you check your email, Facebook, or Twitter accounts?

7. What is more suitable for you

- a. the touch based screen
- b. the buttons based screen

8. In your car, do you like to

- a. check photos
- b. listen to music
- c. watch videos

9. When in a car, how do you reserve a table at a restaurant?

- a. call
- b. online
- c. none of the above

If none of the above, explain -----

10. When in a car, how do you buy movie tickets?

- a. call
- b. online
- c. none of the above

If none of the above, explain -----

11. How often do you use your phone in a car for audio calls?

- a. frequently
- b. moderately
- c. rarely
- d. never

12. How often do you use your phone in a car for text messages?

- a. frequently
- b. moderately
- c. rarely
- d. never

13. When in a car, how do you find the route to a new place?
- a. call someone
 - b. use a navigation system
 - c. ask anyone outside
14. What would you prefer to do when you are lost on the road?
- a. call somebody who will guide you given your current location
 - b. check a navigation system
 - c. ask anyone outside
15. While in a car, would you like to be updated on the actual traffic and weather conditions? If so, how?
- a. voice message
 - b. text

16. How do you usually share multimedia contents like music, video, and photo with your friends?

17. What features would you add to the infotainment system in your car to make your trip more enjoyable and efficient?

Other Comments:-----

A.2 First Mock-up Prototype Usability Task Scenarios

User Number : -----

Please perform the following tasks:

1. Go to Radio Stations and do the following:
 - a. Choose the “Quick Mix Radio” station from the Radio Stations list.
2. Play the CD and listen to “Shereen Kattar Kherry”
3. Go to Digital Audio and do the following:
 - a. Play a music file called “Rashid Jabbar”
 - b. Add the file to My Favourite Music
4. Take a picture and save it in your Photos list.
5. Play the DVD.
6. Use Google search to search for YouTube.
7. Search for a video called “Beauty and the Beast” in YouTube.
8. Create a new account in
 - a. Facebook
9. Check your email inbox, and read the message that was sent by Ehab737.
10. Check the weather for today.
11. Go to your Cars list and do the following:
 - a. Add “Nadeen’s car” to your car list.
 - b. Chat with Ehab’s car.
 - c. Find the location of Ehab’s car.
 - d. Send “Just Go with it” movie to Ehab’s car.

12. Go to Restaurant Services and do the following:
 - a. Search “Red Lobster” and add it to Restaurants list.
 - b. Check the menu at “Red Lobster”.
 - c. Send an invitation to Ehab’s car to go with you to “Red Lobster” on Feb. 15 at 7pm.
 - d. Since Ehab’s car accepts your invitation, make a reservation at the restaurant.
13. View the location of the “Ottawa Greek Summer Festival” on the map.
14. In Movie Tickets, do the following:
 - a. Watch the trailer of “Beauty and The Beast” in SilverCity Gloucester” theatre.
 - b. If you like the movie, buy three tickets for your family.
15. If you are in danger, what do you have to do?
16. Delete “Queensway Carleton Hospital” from your Health Institute list.
17. Check the condition of the car’s wheels.
18. Check the price of petrol in the UK.
19. Go to “Red Lobster” restaurant at 1499 St. Laurent Blvd, then add it to your Favourite Locations.
20. Check your schedule.
21. See your social summary.

A.3 First Mock up Tasks' Paths

- Task 1: Listen to a radio station: Main Menu > Local Multimedia > Audio > Radio > “Quick Mix Radio”.
- Task 2: Play CD: Main Menu > Local Multimedia > Audio > CD > “Shereen Khatar Kherry”.
- Task 3:
 - a. Play an audio file in digital audio: Main Menu > Local Multimedia > Audio > Digital Audio > “ Rashid Jabbar”.
 - b. Add an audio file to favourite: Main Menu > Local Multimedia > Audio > Digital Audio > “ Rashid Jabbar” > Add to Favourite.
- Task 4: Take photo and save it: Main Menu > Local Multimedia > Photos > Take Photo > Take Photo icon > Save.
- Task 5: Play DVD: Main Menu > Local Multimedia > Video > DVD.
- Task 6: Search for a website: Main Menu > Internet Access > Google Search > Search key “YouTube” > YouTube.
- Task 7: Search YouTube: Main Menu > Internet Access > Social Network > YouTube > Search key “Beauty and the Beast”.
- Task 8: Create Facebook account: Main Menu > Internet Access > Social Network > Facebook > Create Account > Enter First Name > Enter Last Name > Enter Email Address > Choose Country > Choose Language > Enter Password > Repeat Password > Create Account.
- Task 9: Check email: Main Menu > Internet Access > Email Access > Enter Email Address > Enter Password > Inbox > “hoba737”.
- Task 10: Main Menu > Internet Access > News > Weather.
- Task 11:
 - a. Add car to cars list: Main Menu > Info Sharing > Add Icon > Enter car Name > Enter car Number > Save.

- b. Chat with another car: Main Menu > Info Sharing > “Ehab’s Car” > Chat > Write Message > Send Message.
 - c. Share Location: Main Menu > Info Sharing > “Ehab’s Car” > Find Location.
 - d. Share Video: Main Menu > Info Sharing > “Ehab’s Car” > Infotainment Sharing > Send Video > Choose a Video > “Just Go With it” > Send.
- Task 12:
 - a. Add restaurant to restaurants list: Main Menu > Touristic Services > Restaurant Services > Search Restaurant > Enter Restaurant Name > Search > Select Add icon from the First Result > Save.
 - b. Check Menu: Main Menu > Touristic Services > Restaurant Services > “Red Lobster” > Check Menu.
 - c. Send Invitation: Main Menu > Touristic Services > Restaurant Services > “Red Lobster” > Send Invitation > Car List > “Ehab’s Car” > Save > Reservation Schedule > “Feb 15 at 7 p.m.” > Save > Send.
 - d. Make Reservation : Main Menu > Touristic Services > Restaurant Services > “Red Lobster” > Choose Date > Choose Time > Choose Party > Enter User’s Name > Enter User’s Email > Confirm.
- Task 13: View Map: Main Menu > Touristic Services > Cultural Event Services > “Ottawa Greek Summer Festival” > Map Location.
- Task 14:
 - a. Watch Movie Trailer: Main Menu > Touristic Services > Movie Ticket Services > “Silver City”> Movie Time Table > “Beauty and the Beast” > Watch Trailer.
 - b. Buy Ticket: Main Menu > Touristic Services > Movie Ticket Services > “Silver City”> Movie Time Table > “Beauty and the Beast” > Watch Trailer > Buy Ticket > Choose a date > Choose the Ticket Type and Price > Enter User’s Name > Enter User’s Email > Confirm.

- Task 15 : Fire and Rescue: Main Menu > Emergency Services > Fire and Rescue > Send Code to Control Center

OR

Main Menu > Emergency Services > Fire and Rescue > Call Fire and Rescue Services.

Task 16: Delete from list: Main Menu > Emergency Services > Health and Safety > Health Institute > Edit > “Queensway Carleton Hospital” > Delete.

- Test 17: Check Cars Wheels: Main Menu > Car Info > Car Maintenance Info > Check Wheels Condition.
- Task: 18: Search location: Main Menu > Navigation System > Where To? > Search address > Enter Address > Go.

OR

Main Menu > Navigation System > Where To? > Points of Interest > Food > Search All Food > Red Lobster > Go.

- Test 19: Check Petrol price: Main Menu > Car Info > Petrol Info > Petrol Prices > Choose a country “UK” > Search Result.
- Test 20: Check Schedule: Main Menu > My Schedule >
- Task 21: Check Social Summary: Main Menu > Social Summary.

A.4 First Mock-up Prototype User Satisfaction Questionnaire

Participant's Number: -----

Please answer the following questions by choosing one or more answer/s:

1. It is very easy to learn how to use the system.
 - a. Strongly disagree
 - b. Disagree
 - c. Neutral
 - d. Agree
 - e. Strongly agree

2. The most interesting functions in the system is/are:
 - a. Local Multimedia
 - b. Internet Access
 - c. Emergency Services
 - d. Info Sharing
 - e. Touristic Services
 - f. Car Info
 - g. Navigation System

3. I like the sequences of operations.
 - a. Strongly disagree
 - b. Disagree
 - c. Neutral
 - d. Agree
 - e. Strongly agree

4. The terminologies used are:
 - a. Easy to understand
 - b. Difficult to understand
 - c. Neutral

5. The method used for adding, editing, or deleting an object is:
 - a. Clear
 - b. Ambiguous

6. The font size is:
 - a. Big
 - b. Small
 - c. Suitable

7. The font color is:
 - a. Clear
 - b. Unclear

8. The pictures used are:
 - a. Meaningful
 - b. Meaningless

9. I like the combination of pictures and text in the system.
 - a. Strongly disagree
 - b. Disagree
 - c. Neutral
 - d. Agree
 - e. Strongly agree

10. The system functions are very:
 - a. Useful
 - b. Important
 - c. Useless
 - d. Distracting

11. What is more suitable for you?
 - a. the touch based screen

- b. the buttons based screen

12. As a driver, I would often:

- a. Listen to music
- b. Access the Internet
- c. Share information with another car
- d. Use touristic services
- e. Check my car info
- f. Use the navigation system

13. As a passenger, I would often:

- a. Listen to music
- b. Access the Internet
- c. Share information with another car
- d. Use touristic services
- e. Check my car info
- f. Use the navigation system

14. I was very comfortable when I used the system.

- a. Strongly disagree
- b. Disagree
- c. Neutral
- d. Agree
- e. Strongly agree

15. I would like to buy a car that has a similar system.

- a. Strongly disagree
- b. Disagree
- c. Neutral
- d. Agree
- e. Strongly agree

16. What did you like most about the system?

17. What did you dislike most?

Any comments

A.4 Second Functional Prototype Usability Test Tasks Scenarios

Please perform the following tasks:

- **As a driver do the following tasks:**

1. Listen to “Shereen Kattar Kherry” in the CD then add it to your Favourite Music.
2. Go to “Red Lobster” restaurant at 1499 St. Laurent Blvd.
3. If you are in danger, what do you have to do?
4. In Car info, do the following:
 - a. Check the condition of the car’s wheels.
 - b. Check the price of petrol in Ottawa.
5. If you want to take the highway and you want to check for traffic incidents, which function in the system would you use?

- **As a passenger do the following:**

1. Watch “Beauty and the Beast” in your digital videos.
2. Use Google search to search for YouTube.
3. Search for a video called “Brave” in YouTube.
4. Check your email inbox.
5. Search for “Nadeen’s car” then add it to your Cars list.
6. Go to your Cars list and do the following
 - a. Chat with Ehab’s car.
 - b. Find the location of Ehab’s car.
 - c. Take a photo then send it to Ehab’s car
7. Make an appointment at “The Ottawa Hospital” in your Medical Centers list.

8. Go to Restaurant Services and do the following:
 - a. Search for “Red Lobster” and add it to Restaurants list.
 - b. Check the menu at “Red Lobster”.
 - c. Send an invitation to Ehab’s car to go with you to “Red Lobster” on Sep. 15 at 7pm.
 - d. Since Ehab’s car accepts your invitation, reserve a table at the restaurant.
9. View the location of the “Ottawa Greek Summer Festival” in your Events list.
10. In Movie Tickets services, do the following:
 - a. Watch the trailer for “Beauty and The Beast” in “SilverCity Gloucester” theatre in Theatres list.
 - b. If you like the movie, buy three tickets for your family.
11. Check your schedule for today.
12. If you want to see your social summary, which function could allow you to do that?
13. While you are using the system, you receive a message telling you “Ehab’s car invites you to dinner at Red Lobster on Monday Sep. 10 at 7:00 pm”, then you press Decide Later. From where you can review this message?

- **For Child Mode, do the following:**

1. Play DVD.
2. Listen to “Toyor Al Janah” in your “Favourite Music”.
3. Use YouTube to search a cartoon movie called “Tangled”.
4. Check your Facebook account.

A.5 Second Functional Tasks' Paths

- **Driver Mode Tasks:**

- **Task 1:** Driver Mode Main Menu > Local Multimedia > CD > “Shereen Kattar Kherry” > Add to Favorite > YES.
- **Task 2:** There are two possible paths:
 - Driver Mode Main Menu > Navigation system > Where to? > Search Address > Write the address > Search.
 - Driver Mode Main Menu > Navigation system > Where to? > Points of Interest > Spell Name > Write the address > Search.
- **Task 3:** Driver Mode Main Menu > Call Emergency.
- **Task 4:**
 - a. Driver Mode Main Menu > Car Info > Car Maintenance Info > Wheels Condition.
 - b. Driver Mode Main Menu > Car Info > Petrol Info > Petrol Prices.
- **Task 5:** Driver Mode Main Menu > Traffic Video Feed.

- **Full Mode Tasks:**

- **Task 1:** Full Mode Main Menu > Local Multimedia > Videos > Digital Videos > “Beauty and the Beast”.
- **Task 2:** Full Mode Main Menu > Internet Access > Google Search > Write YouTube > Search Result “YouTube”.
- **Task 3:** Full Mode Main Menu > Internet Access > Social media > YouTube > Write “Brave” > Search Result “Brave”.
- **Task 4:** Full Mode Main Menu > Internet Access > Email Access > UI and Password > Sign In > Inbox.
- **Task 5:** Full Mode Main Menu > Info Sharing > Search cars > Nadeen’s Car > Add to the List.
- **Task 6:**
 - a. Full Mode Main Menu > Info Sharing > Cars List > Ehab’s Car > Chat.

- b. Full Mode Main Menu > Info Sharing > Cars List > Ehab's Car > Map Location Sharing > Ask permission > OK.
 - c. Full Mode Main Menu > Info Sharing > Cars List > Ehab's Car > Infotainment Sharing > Send Photo > Camera > Take Photo > Use > Send Photo > YES.
- **Task 7:** Full Mode Main Menu > Emergency Services > Health and Safety > Medical Centers > Medical Centers List > "The Ottawa Hospital" > Make an appointment > Choose Date > Enter Patient's Name > Enter Patient's Phone > Enter Patient's Email > Confirm > YES.
- **Task 8:**
 - a. Full Mode Main Menu > Touristic Services > Restaurant Services > Search Restaurants > Red Lobster > Add to the List.
 - b. Full Mode Main Menu > Touristic Services > Restaurant Services > Restaurants List > Red Lobster > Check the Menu > Dinner.
 - c. Full Mode Main Menu > Touristic Services > Restaurant Services > Restaurants List > Red Lobster > Send Invitation > Choose a Date > Choose a Car > Send > YES.
 - d. Full Mode Main Menu > Touristic Services > Restaurant Services > Restaurants List > Red Lobster > Make Reservation > Choose Date > Choose Number of People > Enter User's Name > Enter User's Phone > Enter User's Email > Confirm > YES.
- **Task 9:** Full Mode Main Menu > Touristic Services > Cultural Events Services > Events List > "Ottawa Greek Summer Festivals" > Map Location.
- **Task 10:**
 - a. Full Mode Main Menu > Touristic Services > Movie Ticket Services > Theatres List > "SilverCity Gloucester" > Movies Time Table > "Beauty and the Beast" > Watch trailer .
 - b. Full Mode Main Menu > Touristic Services > Movie Ticket Services > Theatres List > "SilverCity Gloucester" > Movies Time Table > "Beauty

and the Beast” > Buy Ticket > Choose Time > Choose ticket type and numbers > Enter User’s Name > Enter User’s Email > Confirm > YES.

- **Task 11:** Full Mode Main Menu > My Schedule.
- **Task 12:** Full Mode Main Menu > Social Summary.
- **Task 13:** Full Mode Main Menu > Warning Messages > Receive Invitation > Accept.
- **Child Mode Tasks:**
 - **Task 1:** Child Mode Main Menu > Local Multimedia > Videos > “DVD.
 - **Task 2:** Child Mode Main Menu > Favorite Music > “Toyor Al Janah” .
 - **Task 3:** Child Mode Main Menu > Internet Access > Social media > YouTube > Write “Tangled” > Search Result “Tangled”.
 - **Task4:** Child Mode Main Menu > Internet Access > Social media > Facebook > Enter ID and Password > Sign In.

A.6 Second Functional Prototype Usability Test User Satisfaction

Participant Number: -----

Please answer the following questions by choosing one answer:

1. It is very easy to learn how to use the system.

- a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

2. I like the sequences of operations

- a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

3. The terminology used is easy to understand

- a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

4. The method used for adding and deleting an object is clear

- a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

5. The font size is suitable

- a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

6. The font color is clear

- a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

7. The pictures used are meaningful

- a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

8. I like the combination of pictures and text in the system.

- a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

9. The functions of the system are useful

a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

10. I feel that using system functions allows me to achieve a very high degree of productivity.

a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

11. Infotainment services can do all the things I would need.

a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

12. I have not faced any difficulties while using the system.

a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

13. I was very comfortable when I used the system.

a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

14. I would like to buy a car that has a similar system.

a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

15. What did you like most about the system?

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