

**Ford/Google Venture**  
In-Vehicle Internet Connectivity  
Milestone #4

**Tartan Consulting**

Jessica Fung

Ryan Hung

Sung Uk Ryu

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# Scope Statement

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The purpose of this document is to visualize the various design elements associated with the navigation aspect of the autonomous vehicle. In response to the new challenges faced by autonomous vehicles, we centered our design proposals around key attributes:

## **Accessibility**

With the capability of autonomous driving, the ability to control a vehicle remotely becomes a necessary. With the ability to control your vehicle remotely, a car owner can control the vehicle without physically being in the car. Our proposed design will consist of the development of a cross-platform navigating solution. In the vehicle, a main screen will be located in the center of the vehicle between the driver and front passenger seat. From both the in-vehicle interface and mobile application, Ford owners will have the ability to manage their vehicles, request car movement, and share vehicle usage from any internet-enabled device such as a smartphone, tablet, or their vehicle.

## **Simplicity**

Although the technology behind developing the autonomous vehicle is highly sophisticated and complex, the ability to operate the vehicle should require little to no technological expertise. Using standard design conventions modeled after other forms of navigation such as GPS for our in-vehicle interface, and Google Maps for our mobile application, we hope to provide a familiar interface based on previous navigation methods (GPS, Google Maps) for using the vehicle.

## **Security**

With ease of access and ease of use, it is imperative to employ security measures to ensure that vehicle usage is properly managed and monitored. With dual factor authentication, suspicious activity monitoring powered by Google, mobile access to the car is secure with active monitoring to minimize response time should security be compromised.

## ***Other Considerations***

### **Legacy Systems**

In order to aid in the transition toward autonomous driving, we plan to include legacy packages within all our vehicles. This package will include traditional driving capabilities, physical profile linked keyfob security, as well as assisted manual driving transitions for those wishing to take the wheel on their travels.

# In-Vehicle Navigation System

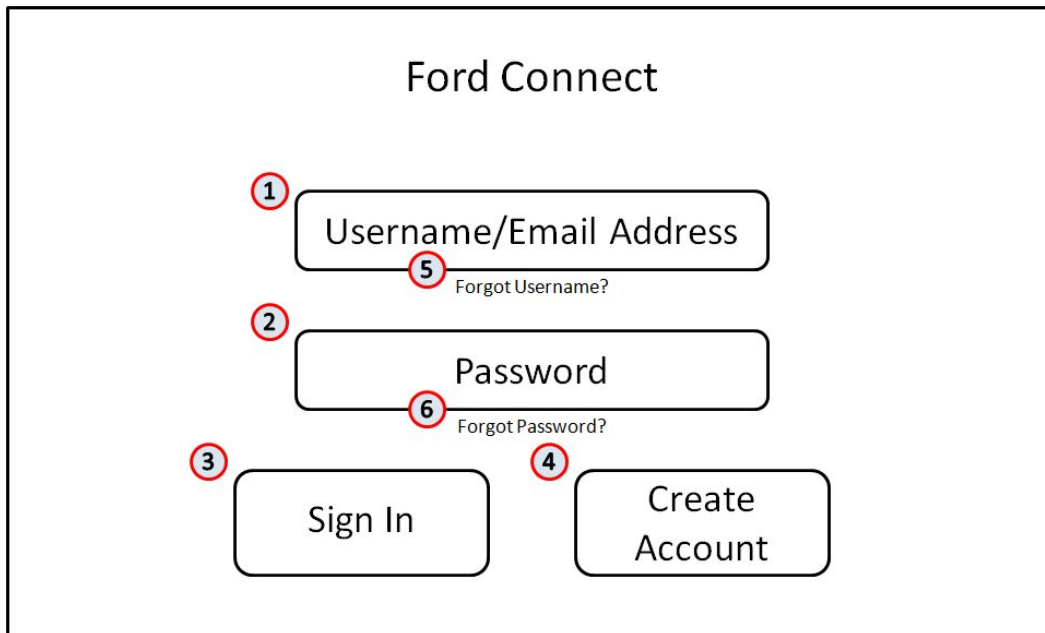
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The in-vehicle navigation system will be controlled via a main screen located in the center of the vehicle between the driver and passenger seat of the car. The system will be run on Chrome OS and the navigation will be a preinstalled application on the system.

The following wireframes depict the various features of the navigation application as well as provide a base model for which the user will see upon completion of design and testing.

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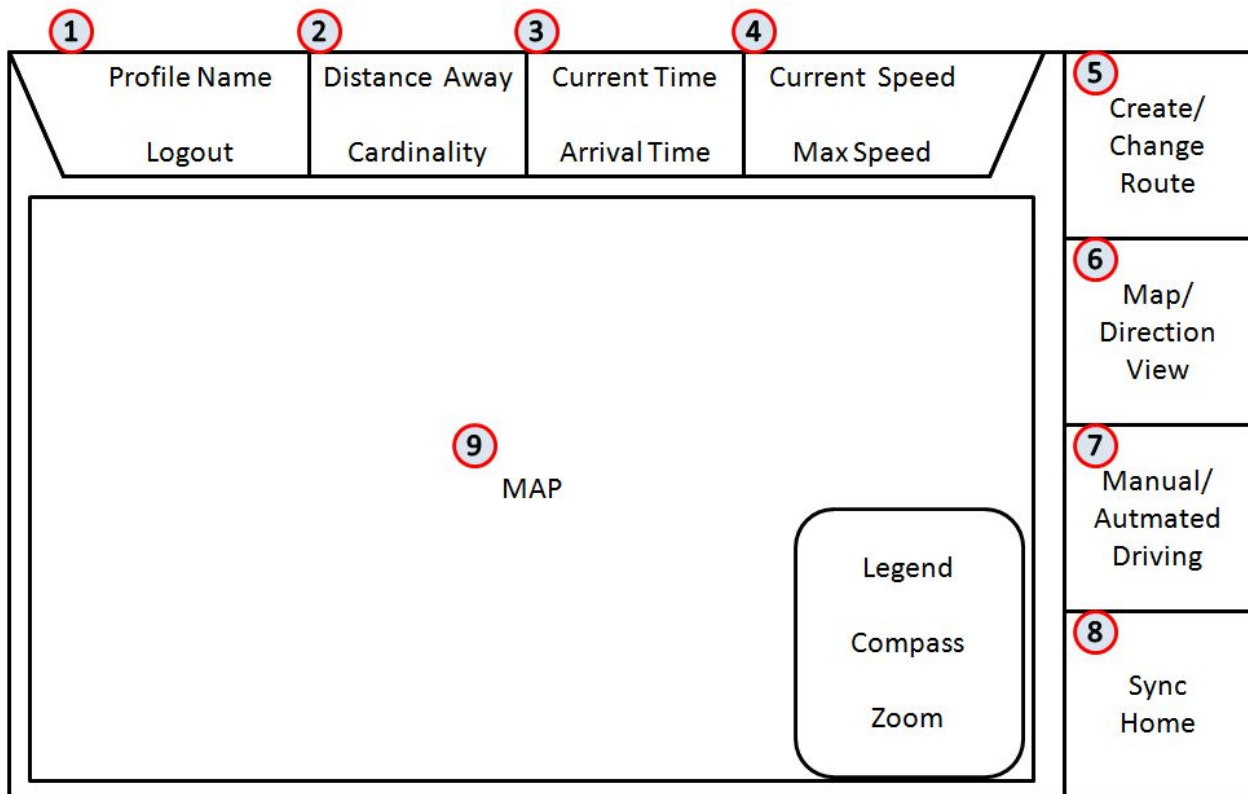
# Login Screen



The diagram illustrates the Ford Connect login screen layout. At the top center is the text "Ford Connect". Below it are two input fields: "Username/Email Address" and "Password". The "Username/Email Address" field has a red circle with the number 1 to its left and a red circle with the number 5 below it, with the text "Forgot Username?" underneath. The "Password" field has a red circle with the number 2 to its left and a red circle with the number 6 below it, with the text "Forgot Password?" underneath. Below the input fields are two buttons: "Sign In" on the left and "Create Account" on the right. A red circle with the number 3 is to the left of the "Sign In" button, and a red circle with the number 4 is to the left of the "Create Account" button.

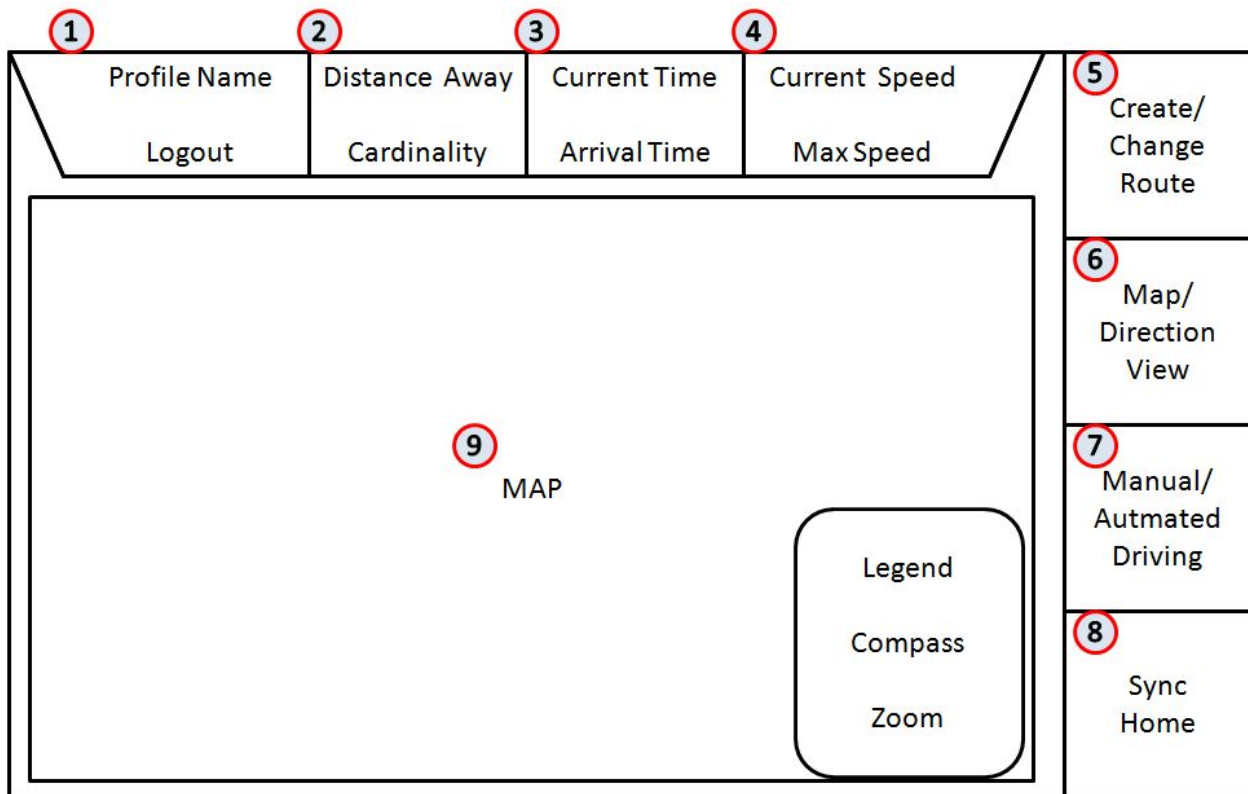
1. Username can be any assortment of letters and character. Each vehicle will remember the username of users if allowed (see **Profile Manager**).
2. Password must be at least 7 characters long, require an uppercase letter, a lowercase letter, a number, and one special character. If an incorrect password is entered, a message appears to remind the user of the necessary elements to the password. If five attempts fail within 5 minutes, the vehicle will lock down (system and car). Upon locking, the user must wait 5 minutes or receive an unlock code sent to the car owner's email or phone. The message to the vehicle owner contains the username, time, and code to unlock the car. The message also prompts an easy police alert button to investigate the vehicle.
3. Upon signing in, the user is brought to the home navigation screen.
4. This button will link to the Ford web portal where a new account can be created. New accounts require authentication from the car owner to drive the vehicle, even if created from inside the vehicle.
5. This link sends the proper username to an attached secondary email to the account. If none exists, the vehicle alerts the car owner of the trouble.
6. This link allows the user to input a username and answer its corresponding security question. If correctly answered, an email is sent to the username's email to reset the password.

## Navigation (Map View)



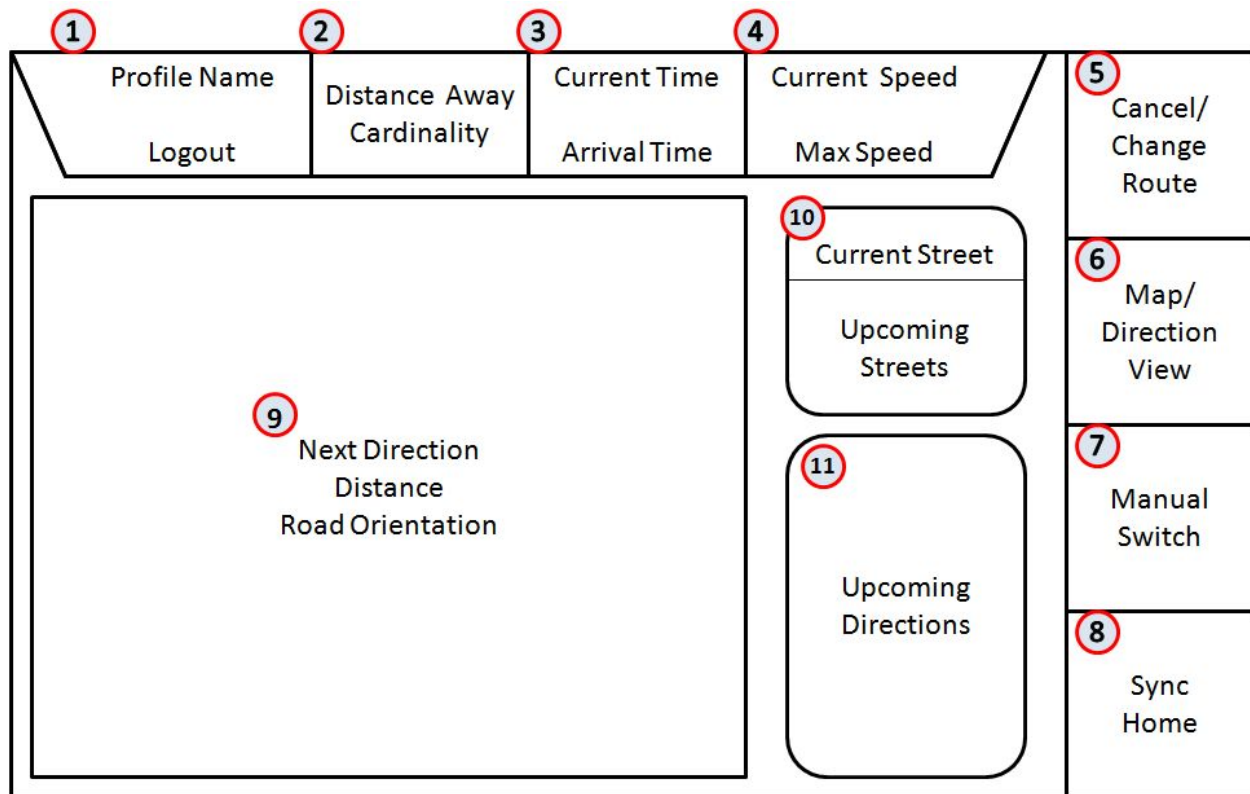
1. This button lists the username of the current vehicle user. If clicked, this brings the user to the screen titled “Profile Manager”. If the logout button is pressed, the user clicking is prompted again to log out. A vehicle cannot be logged out if the vehicle is in motion.
2. This button lists the distance from a destination (if any) along with the units. By clicking this button, the user can change the units that the distance is presented in (imperial vs metric). The cardinality shows abbreviations of directions (N,NE,E,SE,S,SW,W,NW).
3. This button shows the current time and the time of arrival. The time of arrival is estimated based on speed trends and traffic as well as taking into account changes in time zone. By pressing this button, the user can change the presentation of the time (standard vs. imperial).
4. This button displays the current speed of travel as well as the maximum speed limit in the given zone of travel. By clicking this button, the user can convert between units (imperial vs metric).

## Navigation (Map View Cont.)



5. Clicking this button opens a new pop out window (see **Destination Manager**).
6. By clicking this button, the user can change between map view and direction view.
7. Clicking this prompts a second prompt to switch between manual driving or automated driving. The vehicle must be stopped to ensure safety before pressing this button. This button is only be available if the username has a registered drivers license number.
8. This button brings the user back to the vehicle's sync homepage where they have the ability to control other features within the vehicle such as temperature control and infotainment.
9. The map view will use the Google Maps interface. From here the user can input fine grain controls at the highest zoom rate, which will have data streamed in locally from devices on the vehicle.

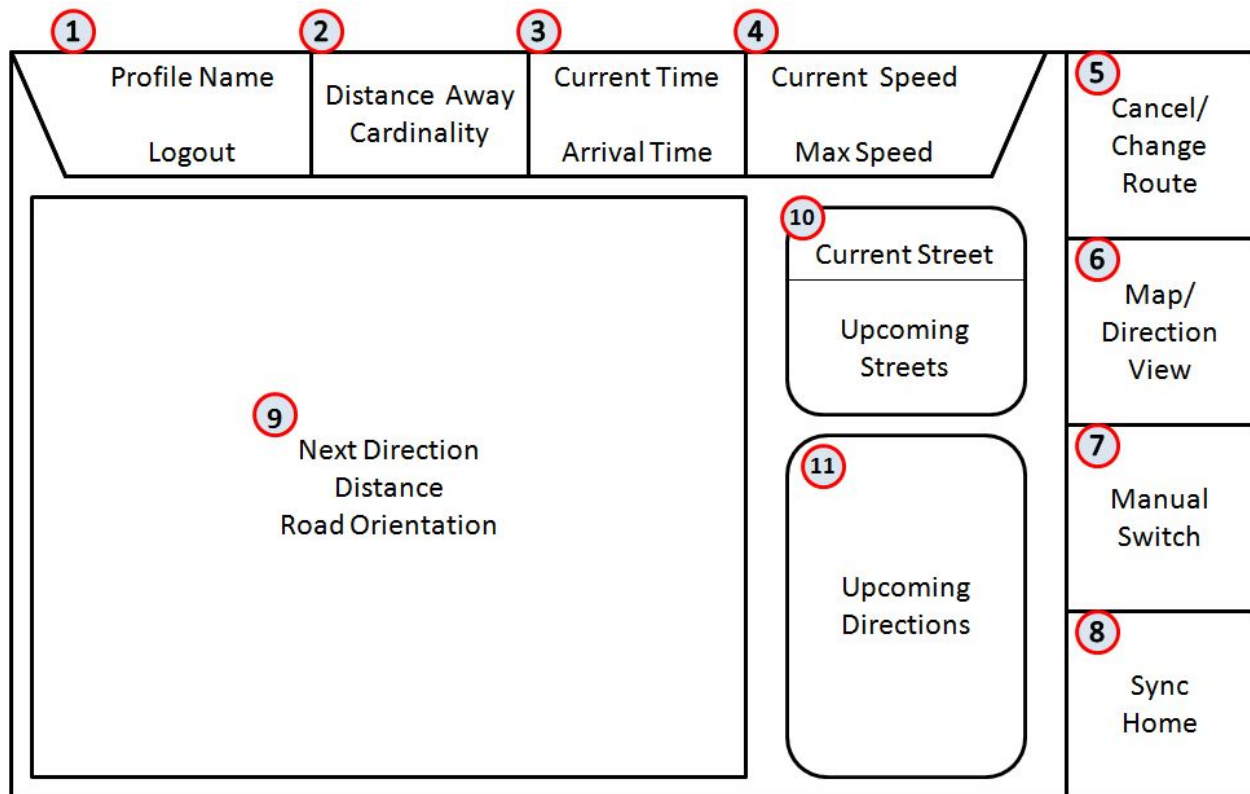
## Navigation (Direction View)



1. This button lists the username of the current vehicle user. If clicked, this will bring you to the profile page. If the logout button is pressed, the user clicking is prompted again to log out. A vehicle cannot be logged out if the vehicle is in motion.
2. This button lists the distance from a destination (if any) along with the units. By clicking this, the user can change the units that the distance is presented in (imperial vs metric). The cardinality shows abbreviations of directions (N,NE,E,SE,S,SW,W,NW).
3. This button displays the current time and the time of arrival. The time of arrival is estimated based on speed trends and traffic as well as taking into account changes in time zone. By pressing this button, the user can change the presentation of the time (standard vs. imperial).
4. This button shows the current speed of travel as well as the maximum speed limit in the given zone of travel. By clicking this button the user can convert between units (imperial vs metric).
5. Clicking this button opens a new resizable pop out window (see **Destination Manager**).
6. By clicking this button, the user can change between map view and direction view.

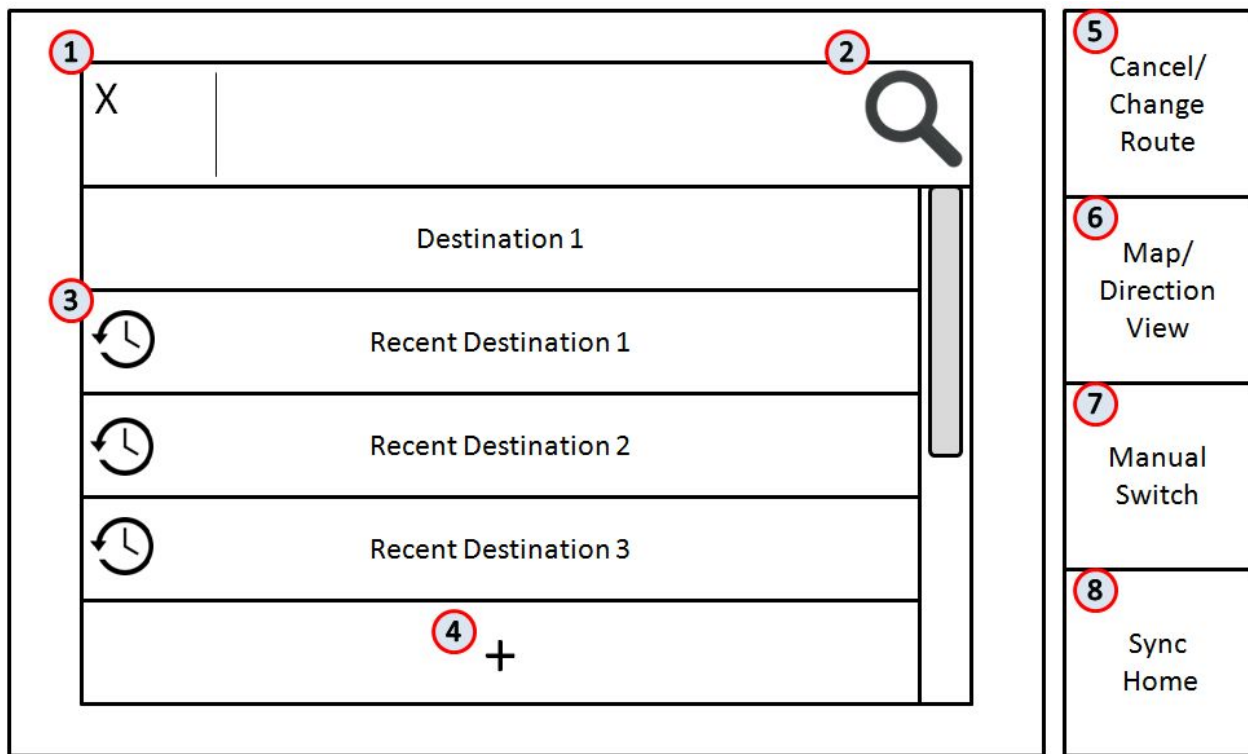


## Navigation (Direction View Cont.)



7. Clicking this prompts a second prompt to switch between manual driving or automated driving. The vehicle must be stopped to ensure safety to select this button. This button will only be available if the username has a registered drivers license number.
8. This button brings the user back to the vehicle's sync homepage where they have the ability to control other features within the vehicle.
9. This area shows the next upcoming direction. This is mainly used for manual or speech-based driving to help the user determine the next immediate move, how far until making the move, and the general layout of the road when the user needs to make the move.
10. This area tracks the upcoming streets. It helps drivers with orientation in ensuring that manual drivers have a better idea of where they are. The area is broken into two sections: the current street you are driving on and the upcoming side streets the driver is passing.
11. This area displays the upcoming directions on the list. It shows the distance that requires travel and major turns required.

## Destination Manager



1. This button closes the popup window, revealing the map/direction view.
2. When clicked, this button returns the results of a search using the criteria placed in the text box in an expanded form.
3. This area contains auto filled results based on what has be placed in the search.
4. This button allows the user to set detours or additional routes after a primary destination has been chosen.
5. Clicking this button closes the Destination Manager popup window, revealing the map/direction view.
6. By clicking this button, the user can change between map view and direction view.
7. Clicking this prompts a second prompt to switch between manual driving or automated driving. The vehicle must be stopped to ensure safety before clicking this button. This button will only be available if the username has a registered drivers license number.
8. This button brings the user back to the vehicle's sync homepage where they have the ability to control other features within the vehicle.

# Profile Manager

The screenshot shows the Profile Manager interface. It includes a car image (1), a text box for 'Vehicle Name/Model' (2), a text box for 'Current User' (3), and a list of 'Authorized Users' (4). The 'Authorized Users' list shows 'Vehicle Owner: USER NAME' in bold, followed by 'USER NAME', and an 'Add New' button with a plus icon. On the right, there is a vertical sidebar with buttons: 'Cancel/Change Route' (5), 'Map/Direction View' (6), 'Manual Switch' (7), and 'Sync Home' (8).

1. This area depicts an image of the current model car which you are inside. Clicking this image brings up a pop out window displaying detailed information about the car including plate number, serial number, and registration information.
2. This area displays the model of your car as well as any nickname you may have given it. Each profile can name the car differently, however the model number cannot be edited. Clicking this box allows the user to change the car's nickname.
3. This area displays the current user of the vehicle. It has no clickable features.
4. This area displays the authorized users of the vehicle. The uppermost name is bolded to denote that this user is the vehicle. A new authorized user may be added from this screen with verification from the car owner.
5. Clicking this button returns the user to the **Navigation (Map View)** and opens the **Destination Manager** pop out window.
6. By clicking this button, the user can switch between map view and direction view.
7. Clicking this button prompts a second prompt to switch between manual driving or automated driving. The vehicle must be stopped to ensure safety before pressing this button. This button will only be available if the username has a registered drivers license number.
8. This button brings the user back to the vehicle's sync homepage where they have the ability to control other features within the vehicle such as temperature control and infotainment.

# Voice Commands

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The goal of voice commands is to provide a more convenient method of controlling the vehicle for various situations such as passengers sitting far from the in-vehicle touchscreen or users who are handicapped. To model this, we used sample dialogues between a user and the voice commands system (VCS)

In the following pages, we focus on the voice commands on the in-vehicle navigation system, however these features are also available for the mobile application as via the traditional voice control activation of the device.

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## Activation

The user can use their voice to operate the navigation system. The voice control system is activated by saying, “OK, Ford.” Once the in-vehicle microphone recognizes the voice activation command, the vehicle responds back and guides the user in utilizing various features in the in-vehicle navigation system with voice commands. Then, the user can say "Navigation" and being to gain access to the navigation system.

**User:** “Ok, Ford.”

**VCS:** “Welcome to Ford Connect, speak the feature you want to use. If you don't know how to use voice system, say 'Help'.”

**User:** “Navigation.”

**VCS:** “Did you you say Navigation?”

**User:** “Yes.”

**VCS:** “Starting navigation system.”

## Functions

Functions used to operate the navigation system using voice commands were designed to be simple, while the in-vehicle navigation interface focuses more on finer details like the fine grain movement required to move a car a bit more to the right or park a car perfectly. The voice commands were designed this way because it is difficult to point out places that can easily be identified and selected by vision and touch on the screen within the vehicle. Therefore, it would be more efficient for the voice commands system on the in-vehicle navigation to only provide functions that can be easily operated by few simple steps: Set Destination, Search Location, Current Location.

*(After activating in-vehicle navigation system)*

**VCS:** “Please say the things you want to do. You can say, ‘Set Destination, Find Places, or Current Location.’”

**User:** (Say a command)

**VCS:** (Repeating recognized voice command)

## Set Destination

Setting a desired destination would be the most popular function of a navigation system. The user can set their destination by saying a previously stored destination name or the exact address of a new destination. If the user says a location which has been previously stored in the navigation system, the system confirms the destination and starts driving. If the user says a new address with a zip code, the navigation confirms the address and starts to drive to the destination. After arriving, user can choose to save the destination.

Here, we demonstrate the two cases: One where the user sets a previously stored location as a destination, and one where the user sets a new location as a detour.

### *Case 1. Setting previously stored location as a destination*

**VCS:** “Set destination. Which place would you like to go? You can say (list few most recently used stored locations) or zip-code of your desired destination.”

**User:** “Tepper.”

**VCS:** “Did you say Tepper?”

**User:** “Yes.”

**VCS:** “Start driving to The Tepper School of Business, 4999 Frew Street, Pittsburgh, PA.”

**User:** “Add Detour. Chipotle.”

**VCS:** “Did you mean Chipotle Mexican Grill?”

**User:** “Yes.”

**VCS:** “Would you like to go to Chipotle Mexican Grill before or after Tepper?”

**User:** “Before.”

**VCS:** “Setting Chipotle Mexican Grill, 4800 Baum Boulevard, Pittsburgh, PA as a detour before traveling to The Tepper School of Business.”

*Case 2. Setting new location as a destination*

**VCS:** “Set destination. Which location would you like to travel to? You can say (list few most recently used stored locations) or zip code of your desired destination.”

**User:** “10019.”

**VCS:** “Did you say 10019, New York, NY?”

**User:** “Yes.”

**VCS:** “Please say exact address of your destination.”

**User:** “11 West 53rd Street.”

**VCS:** “Did you say 11 West 53rd Street, (if the address has a registered place name) The Museum of Modern Art?”

**User:** “Yes.”

**VCS:** “Start driving to the Museum of Modern Art (if the address has a registered place name) / 11 West 53rd Street, New York, NY (if if the address doesn’t have a registered place name).”

*(After arriving the destination)*

**VCS:** “Arriving (Destination) the Museum of Modern Art. Would you like to save this location?”

**User:** “Yes.”

**VCS:** “How would you save this location?”

**User:** “(Saying desired name) MOMA.”

**VCS:** “11 West 53rd Street, New York, NY, 10019 has been saved as MOMA.”



## Search Locations

The user can search certain locations on the navigation system by voice commands. If the user says a certain place's name, the navigation will list the most probable location based on the user's settings and past location history. After choosing a location, the user can either request additional information about the location from the navigation system or choose to set the location as the destination and start driving. Upon arrival, the user can choose to save the destination.

**VCS:** "Search locations. Which location would you like to search? You can say a location name or the type of location you are looking for."

*Case 1. Saying exact location name*

**User:** "Carnegie Mellon University."

**VCS:** "Did you say Carnegie Mellon University?"

**User:** "Yes."

**VCS:** "There is only one Carnegie Mellon University within a 10 miles (or a number based on search results or user setting) and the address is 5000 Forbes Avenue, Pittsburgh, PA. Do you want to set Carnegie Mellon University as your destination?"

**User:** "Yes."

**VCS:** "Driving to Carnegie Mellon University."

*Case 2. Saying generic type of location*

**User:** "McDonalds."

**VCS:** "Did you say McDonalds?"

**User:** "Yes."

**VCS:** "There are 3 McDonalds within 10 miles. Do you want to start driving to the nearest McDonalds?"

*Sub-Case 1. Going to the nearest place*

**User:** “Yes.”

**VCS:** “Driving to McDonalds at 4203 Forbes Avenue, Pittsburgh”

*Sub-Case 2. Choosing other place*

**User:** “No.”

**VCS:** “Which McDonalds would you like to go? The first McDonalds is at 4203 Forbes Avenue, Pittsburgh, the second McDonalds is at 6501 Penn Avenue, Pittsburgh, and the third McDonalds is at 3456 Liberty Avenue, Pittsburgh. You can say the order of your destination.”

**User:** “Second”

**VCS:** “Did you say Second?”

**User:** “Yes.”

**VCS:** “Do you want to set McDonalds at 6501 Penn Avenue, Pittsburgh as your destination?”

**User:** “Yes.”

**VCS:** “Driving to McDonalds at 6501 Penn Avenue, Pittsburgh.”

## Current Location

The user can ask current location on the map by voice command system while driving to the destination. Being asked, the navigation system provides the current location and estimated time until arrival to the destination. Then, the navigation system asks if the user wants to look up faster alternative route. If the user says yes, the navigation system will search another route based on current traffic data and list feasible options.

**VCS:** “Current location. The vehicle is at 1009 Forbes Avenue, Pittsburgh and the estimated time until arrival is 30 minutes. Would you like to search for alternative routes?”

**User:** “Yes.”

*(After searching alternative routes)*

**VCS:** “There is faster route which takes Fifth Avenue and estimated time until arrival for this route is 20 minutes. Would you like to change route?”

**User:** “Yes.”

**VCS:** “Now taking Fifth Avenue”

# Mobile Application Interface

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The goal of the mobile application to act as a partner to the vehicle and the in-vehicle mechanisms. It is not to replace any part, but rather, offer another method of retrieving the same type of information required for navigating the vehicle.

In the following pages, we outline the main options and the functions of the mobile application in the three key areas of navigation, locking, and remote access.

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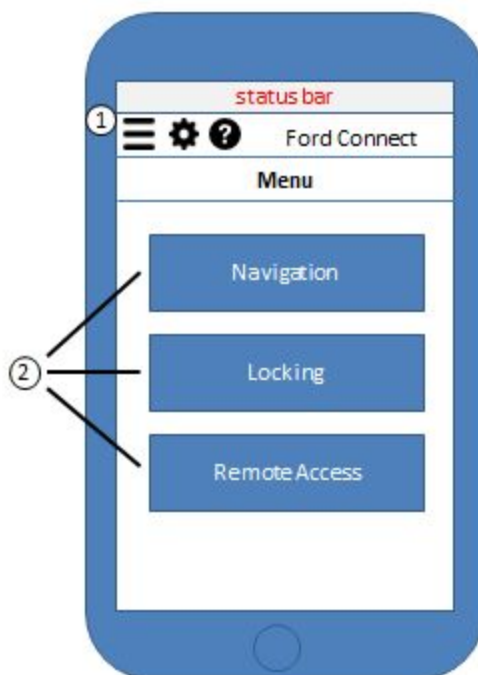
## Main Options

**Start Screen.** Opening the application on a mobile device or tablet prompts the start screen. Incorrect passwords prompt a message displaying the password requirements of containing at least one uppercase letter, one lowercase letter, one number, and one special character.



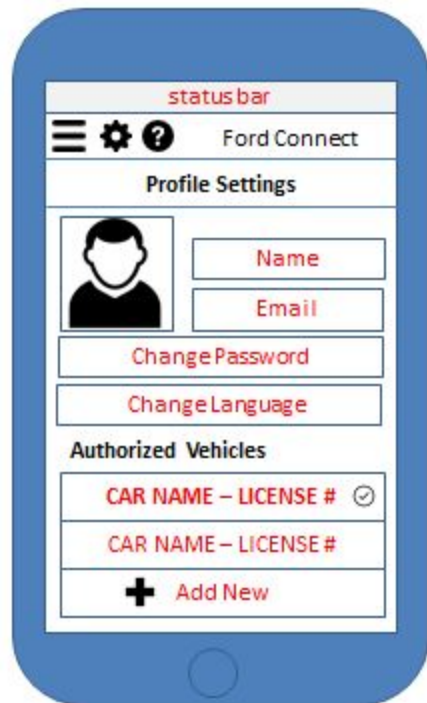
- ① Type in the email and password registered with dealer and press "Enter" to access the application.
- ② The Help Button leads to website FAQ and provides help in safely recovering a forgotten email/password.

**Menu.** Provides options for navigation, locking, and remote access.



- ① Menu (≡), Profile Settings (⚙️), and Help (?) can be accessed from all pages within the application.
- ② Menu provides options for Navigation, Locking, and Remote Access. These can be accessed by clicking on the buttons.

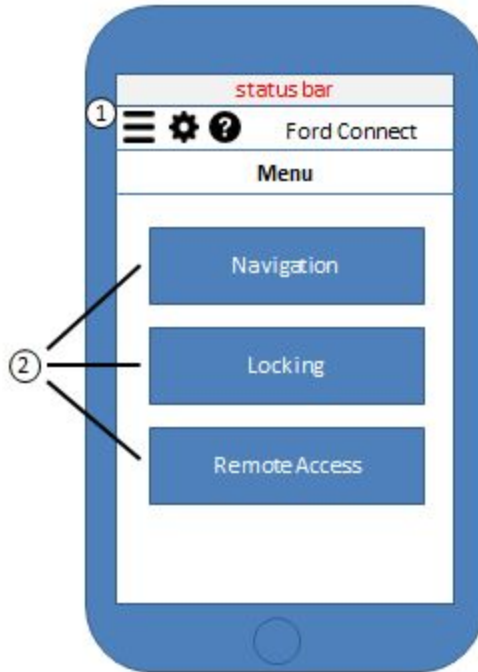
## Profile Settings.



- ① Profile Settings provides options to change profile information and preferences.
- ② Authorized Vehicles section displays vehicles that the user's mobile application has been registered with.
- ③ Bolded/checked vehicle indicates vehicles that are currently in use. Clicking on the vehicle displays information on who is using the vehicle

# Navigation

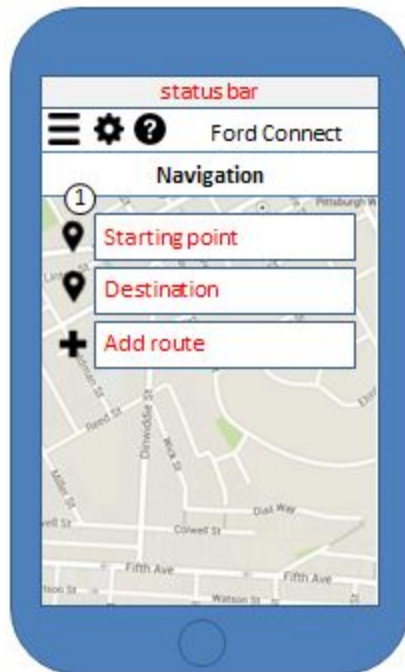
N1. Select the Navigation option from the menu.



① Menu (☰), Profile Settings (⚙️), and Help (❓) can be accessed from all pages within the application.

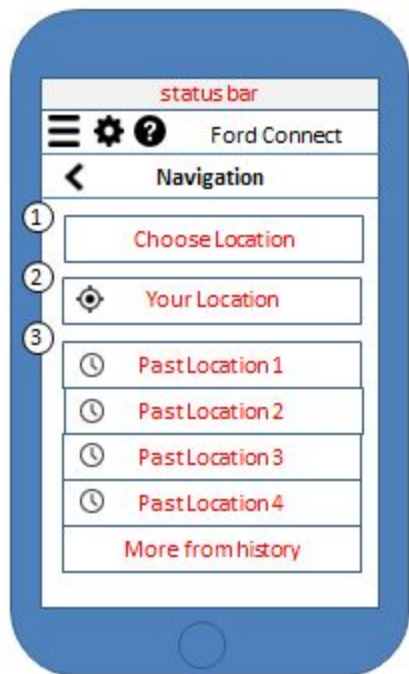
② Menu provides options for Navigation, Locking, and Remote Access. These can be accessed by clicking on the buttons.

N2. Select appropriate fields to fill. At minimum, a starting point and destination are required.



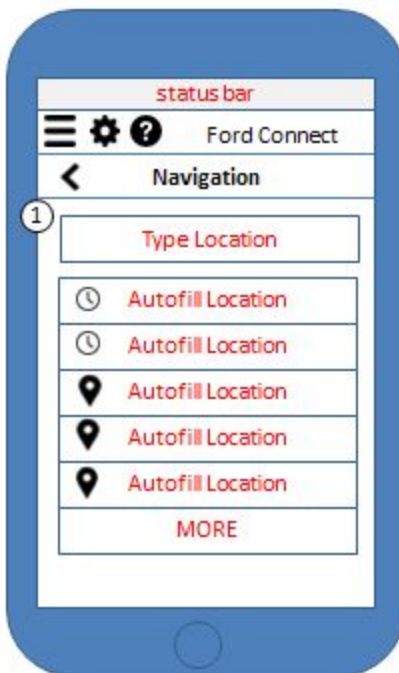
① Click to enter routing information for the starting point, destination, or additional routes.

**N3.** Choose location from options provided or type in location.



- ① Type new location.
- ② Enable location tracking to select current location.
- ③ Select a past location input from the list.

**N4.** Select location from autofill options.

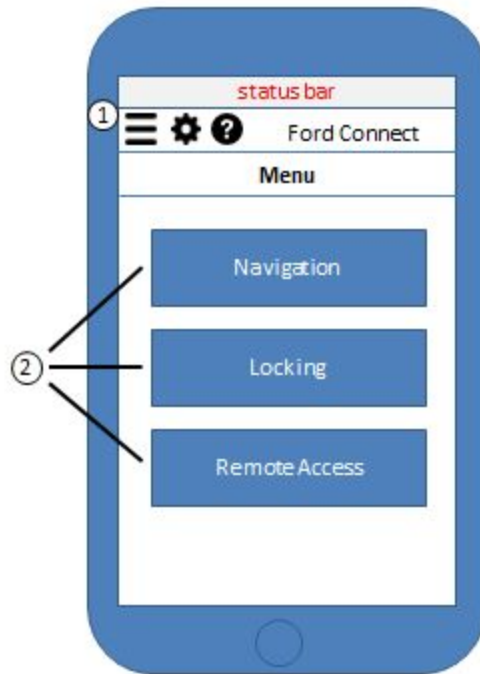


- ① Inputting new location opens a keypad for you to type in a new address. As you type, the application generates a list of auto-filled locations.



# Locking

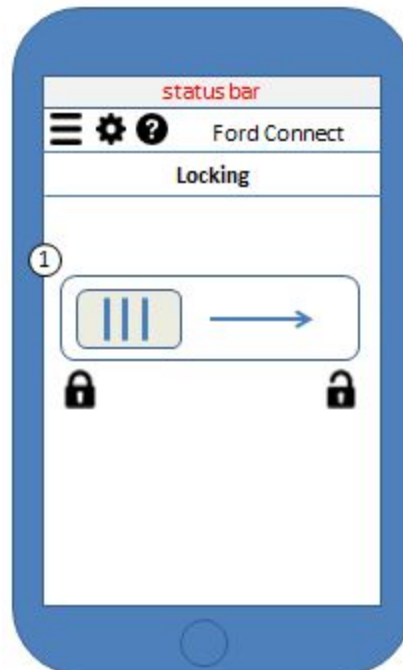
**L1.** Select the Locking option from the menu.



① Menu (☰), Profile Settings (⚙️), and Help (❓) can be accessed from all pages within the application.

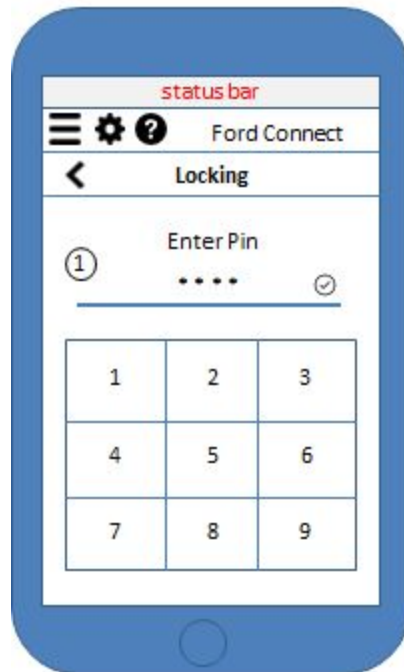
② Menu provides options for Navigation, Locking, and Remote Access. These can be accessed by clicking on the buttons.

**L2.** Swipe the bar to change the lock state.



① Swipe the bar across to lock or unlock the vehicle.

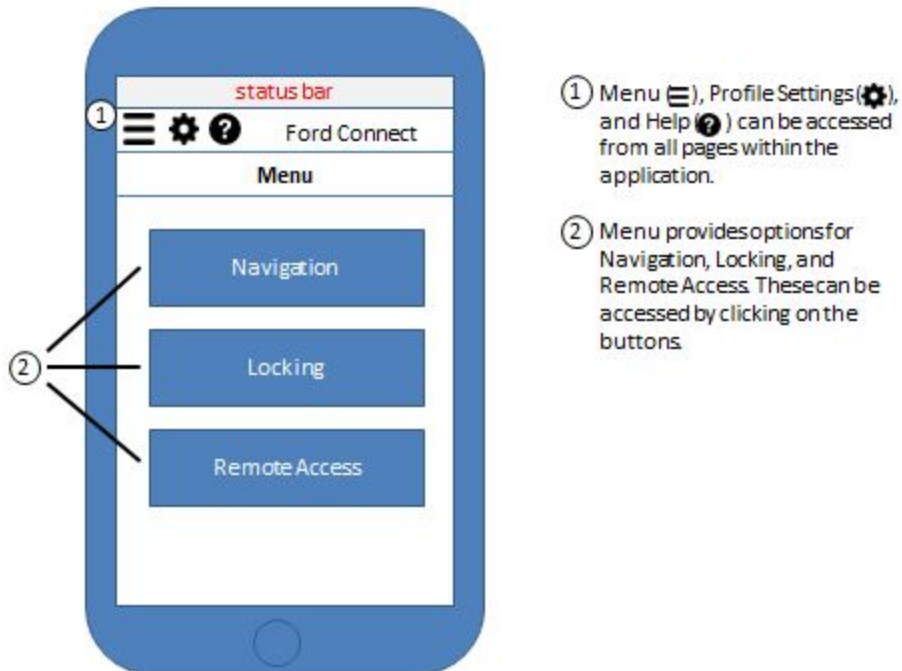
**L3.** The pin code ensures that only those who know the pin can unlock the vehicle.



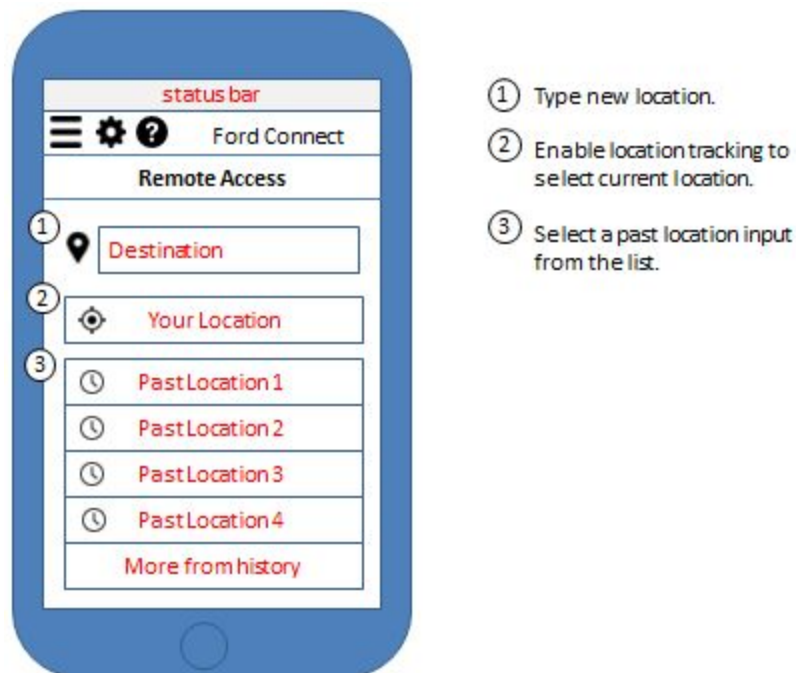
① Input PIN code for secure locking or unlocking. The PIN code is specific to each user.

## Remote Access

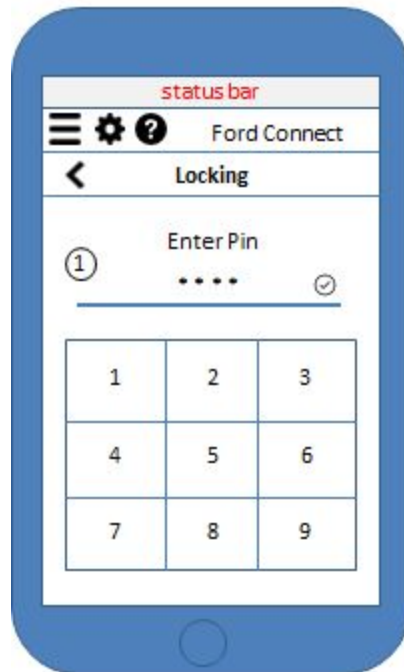
**R1.** Select the Remote Access option from the menu.



**R2.** Choose location from options provided or type in location.

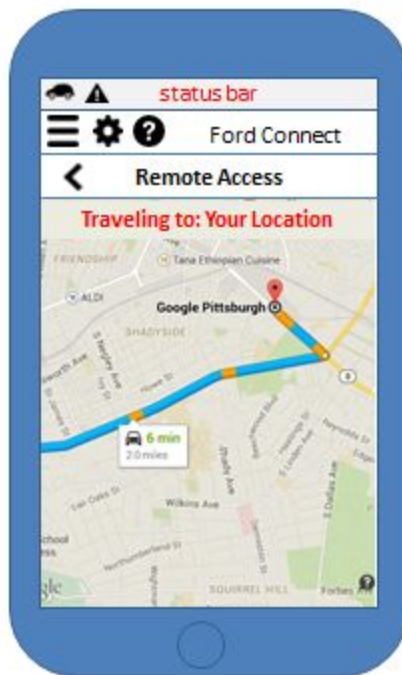



**R3.** The pin code ensures that only those who know the pin can remotely move the vehicle.




① Input PIN code for secure locking or unlocking. The PIN code is specific to each user.

**R4.** A map showing the car's route and its location in the route is displayed. Status icons provide additional information about the vehicle.



 "CAR NAME is traveling to LOCATION. ETA ##:##."

"CAR NAME has arrived at destination."

 "PERSON is using CAR NAME."

"CAR NAME requires repair. Click for details."

# Appendix

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The user interface of the in-vehicle navigation, voice commands, and mobile application rely on the autonomous vehicle's ability to connect to the internet.

In the following pages, we present the class diagrams, sequence diagrams, and state machines for the internet connectivity system.

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# Class Diagram

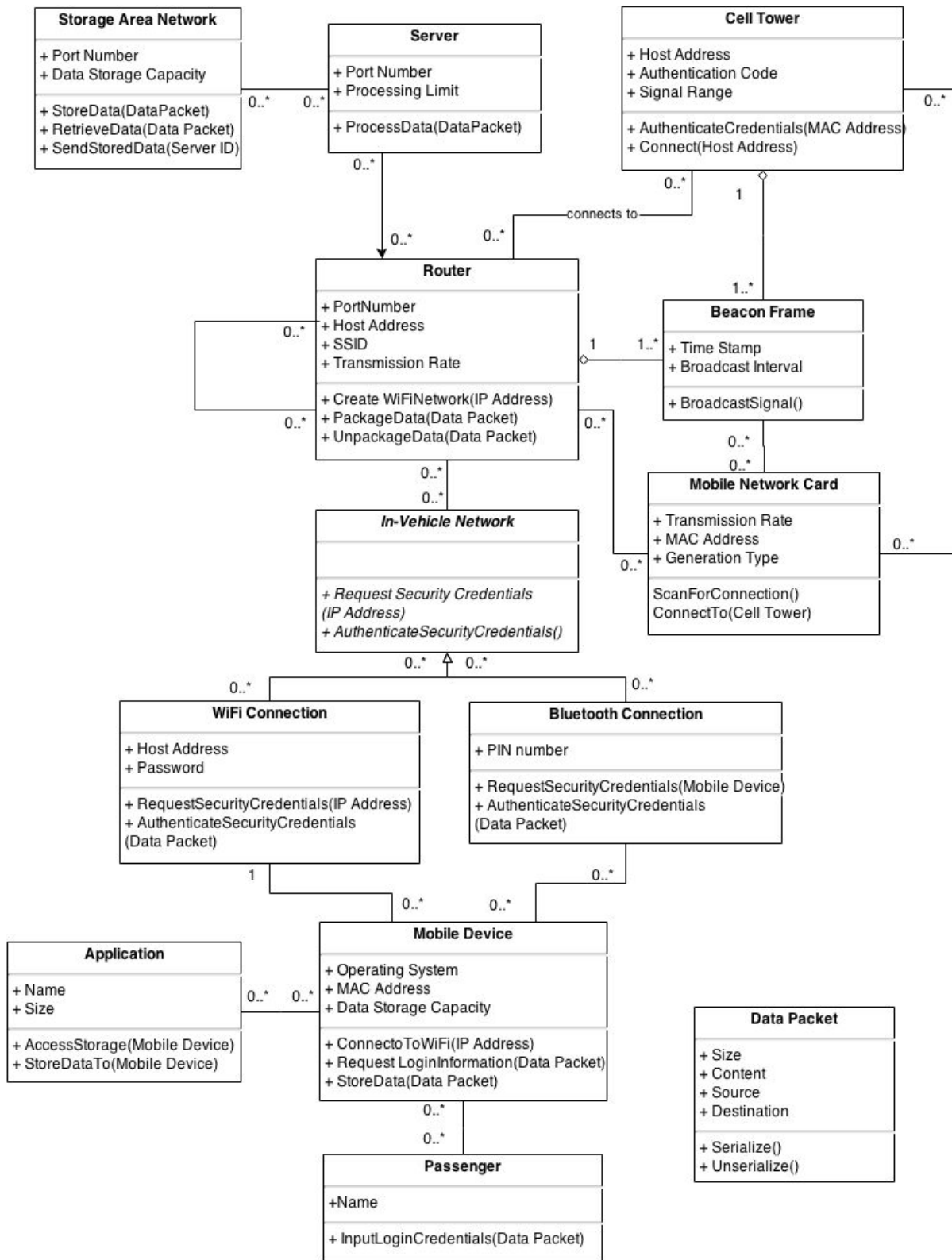
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The following two pages captures the single class diagram titled “Internet Connectivity System”.

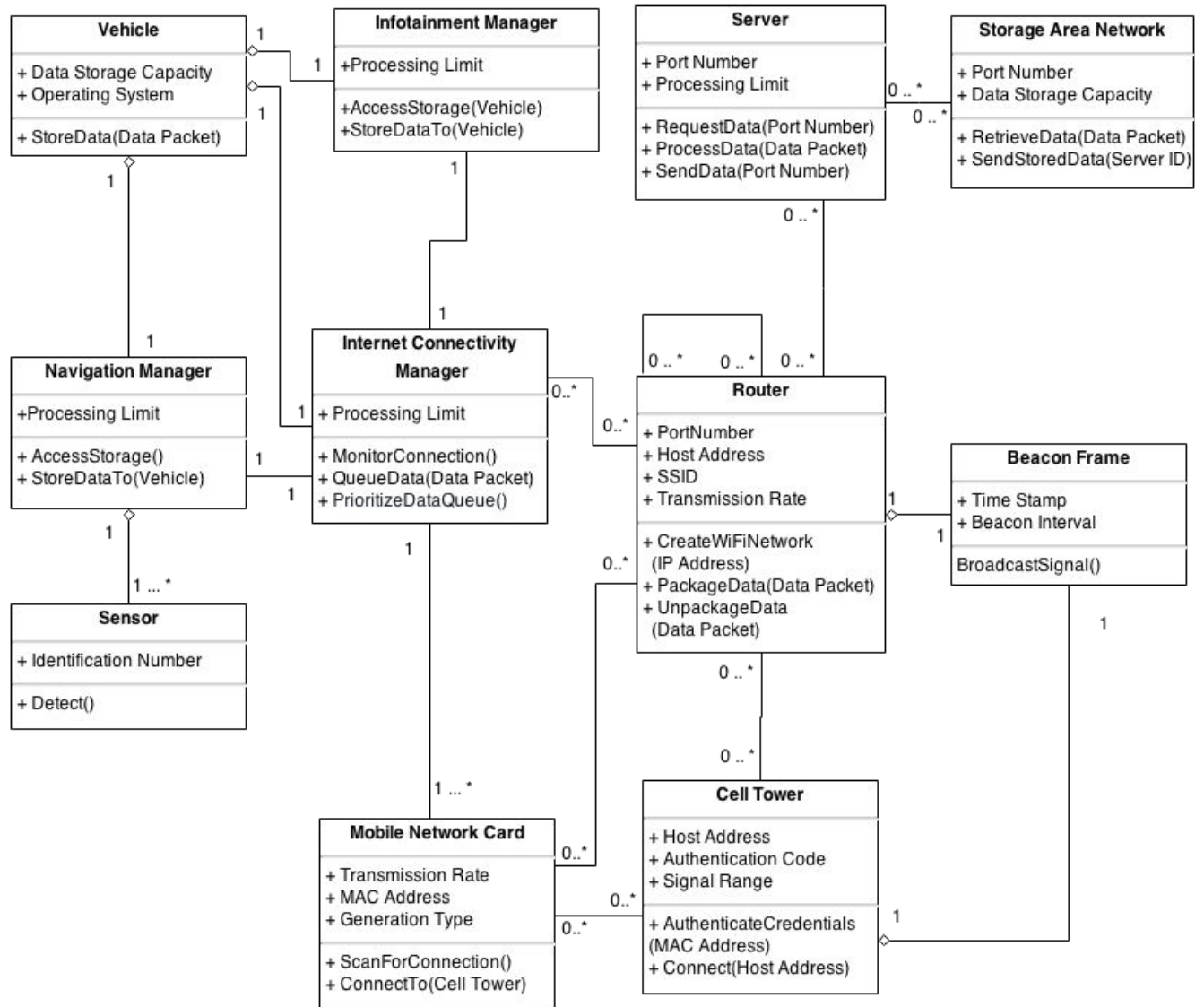
The class diagram captures the key classes we recommend using to implement the system, and each class contains the attributes and methods and modifiers for the class. Relationships between classes are outlined and include cardinality.

---

## Internet Connectivity System



## Internet Connectivity System





# Sequence Diagrams

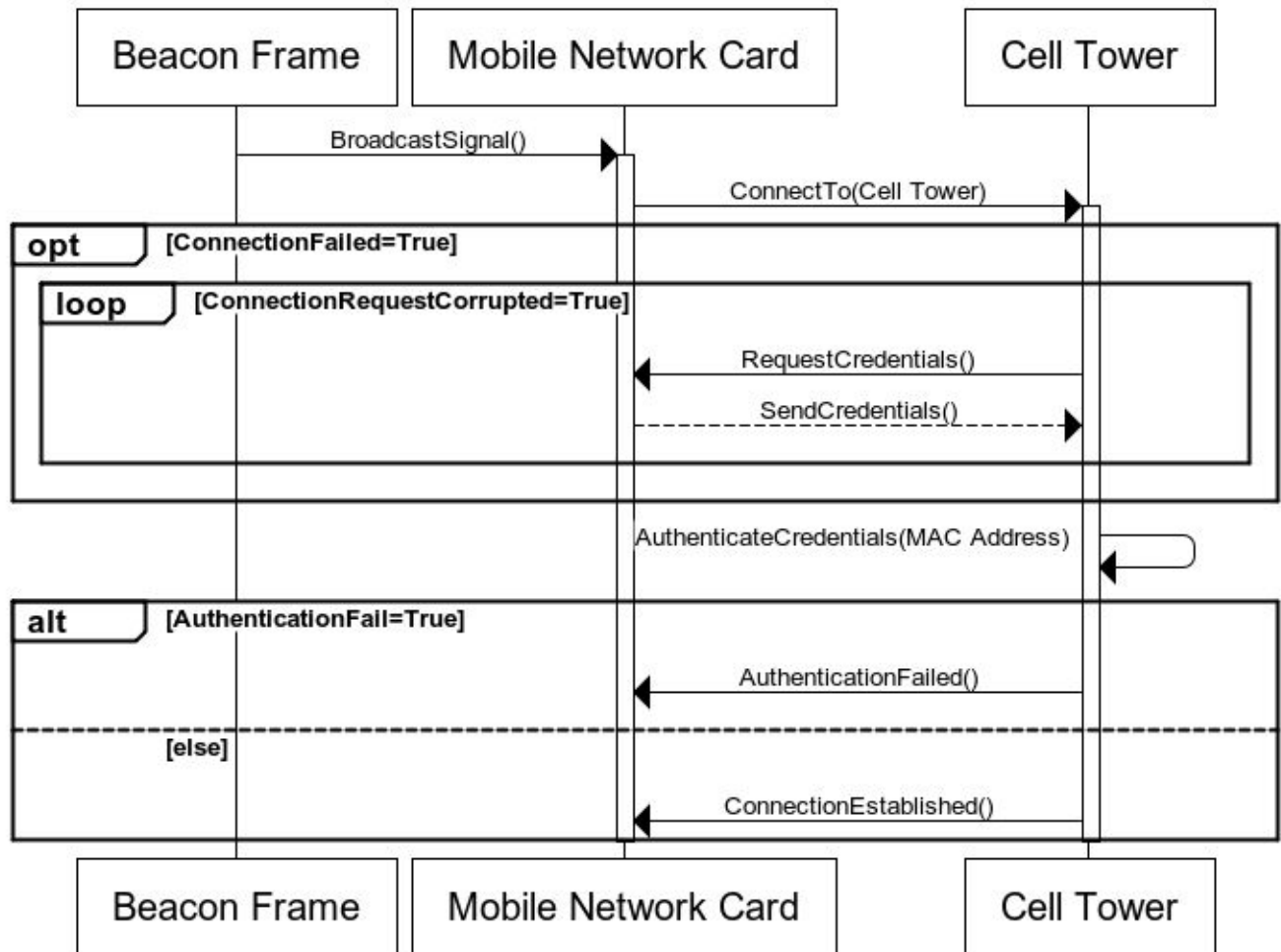
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Sequence diagrams illustrate the timing and sequence of messages exchanged between classes in a use case. It helps provide a visual representation of behaviors by documenting object creation and destruction and showing implementation details and the information exchange between classes within and across implementation layers.

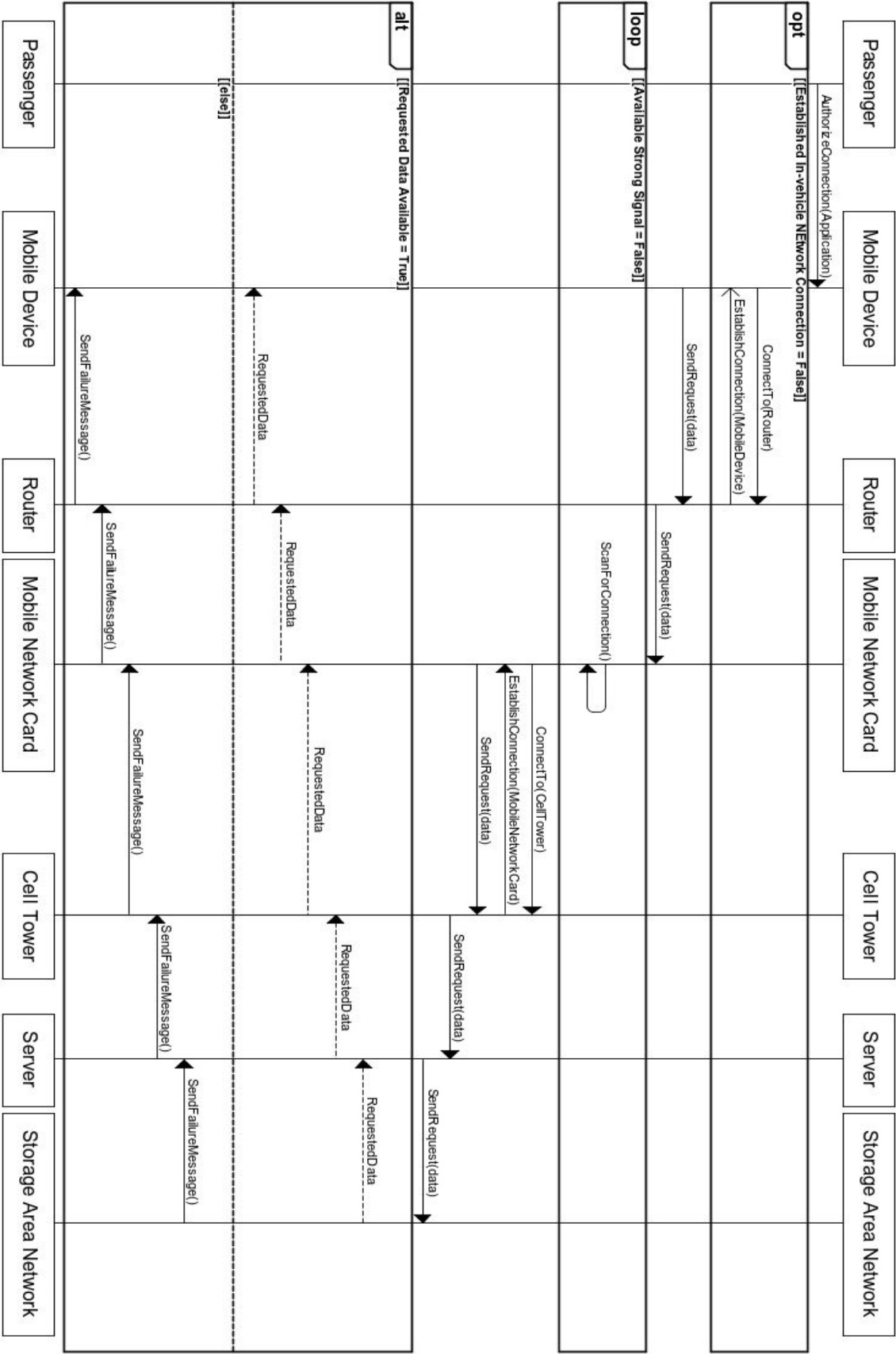
The following three pages provide visualizations of the following use cases:

1. Connecting mobile network card to a cellular network
  2. Requesting data from a mobile device
  3. Prioritizing data requests by the internet connectivity manager
-

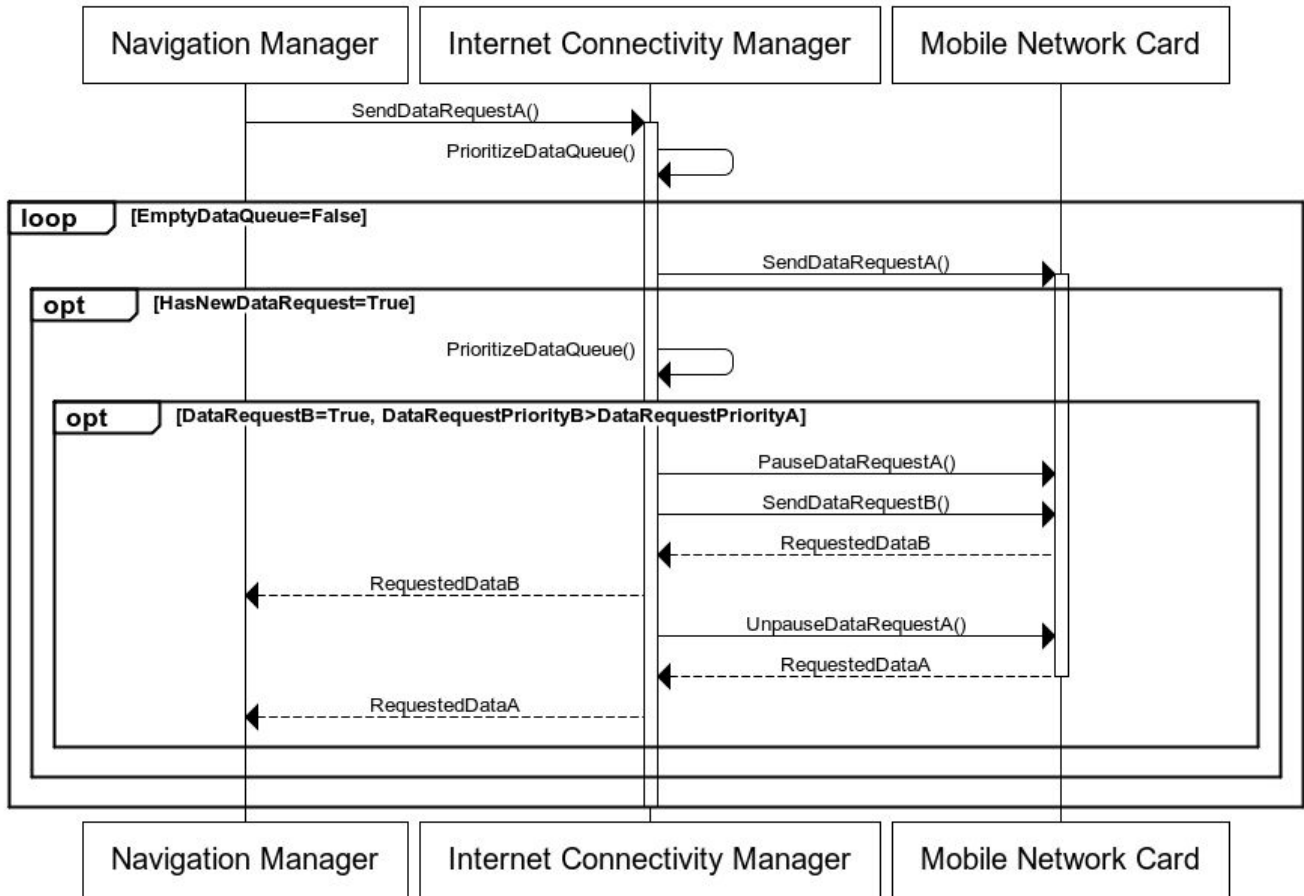
## Connecting Mobile Network Card To a Cellular Network



Requesting Data From a Mobile Device



## Prioritizing Data Requests By the Internet Connectivity Manager



# State Machine Diagrams

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Classes may have various states over the course of its lifetime, and these states can be visually represented in a state machine diagram. A state machine diagram specifies the sequences of states that a single object or class goes through in response to events it encounters.

We selected the internet connectivity manager and the mobile network card as the most dynamic classes within the internet connectivity system and outlined the states for these classes.

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