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A.R.T.I.M.U.S. Phase II

Augmented Reality Tractor Information Management Utility System

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Project Phase I

This application is aimed at providing the owners of John Deere equipment with an easy resource for checking the status of their vehicles. As this project is a continuation of the previous year's work, it is important to recognize the work that was previously accomplished. This will also help clarify the new requirements and work that will be new to the project.

Previous Accomplishments:

- Connection with the MTG
  - Uses TPLink to connect with MTG to create wireless
  - Gather machine information and display it to the user on the device
- Connect to a vehicle using the connection ID
- UI is functional
- Stores account information on the phone
- AR works on small objects

Changes/Additions:

1. Connection with the MTG
   a. New MTG will have on board Wi-Fi chip
   b. Wont need TPLink
2. UI is themed like other John Deere apps
3. Stores data on the cloud rather than the mobile device itself
4. The mobile device becomes the server and the MTG becomes the client
5. Makes the design more secure
6. Send sms to wake MTG if it's not listening
7. AR works on the tractors in the field
8. Displays information to the user
9. Widgets for various areas of the machine
   a. No need for Developer mode
10. All important information will be logged and available

Previous Key Functional Requirements

- Connects directly to MTG device on board the tractor via wireless and downloads maintenance data securely to the mobile device
- Maintenance Information and Alerts—provides information on the maintenance state of the tractor and will display alerts when maintenance parameters pass predefined thresholds.
- Augmented Reality View—provides a point and shoot method to identify a tractor and display maintenance information on this tractor.
- Farmer Mode—provides all the features listed above.
- Dealer Mode—provides all the features of the farmer mode and in addition this mode will allow a dealer to quickly sort, classify, tag, and search for vehicles he has registered on his app.
- Developer Mode—provides all the features of the dealer mode and in addition the app will be able to download logs from the MTG and may provide some information about these logs.

Previous System Requirements

- Runs on Apple's iOS mobile operating system starting from version 7 up to 8
- Must have working camera
- WiFi connectivity must be available on the device and enabled

Previous Issues and Challenges

- Image Recognition on Mobile Devices
- Learning curve for developing with iOS, mobile development, and Augmented Reality
- Security limitations of the iOS system which prevent easy handling of WiFi and other built in libraries provided by the Apple system.

Proposed Non-Functional Requirements

- Store data on the John Deere cloud rather than on the mobile device itself. This allows the account information to be recognized and retrieved from any device rather than just the device it was created on. This will also not have the app use a lot of memory on the device.
- Have the mobile device be the server and the MTG be the client. This allows the MTG to not always be powered on and can either listen or wake up when the server wants to request information from the MTG.
- Implement some standard security practices if the MTG software can support it. This is something that needs to be looked into, as it can be very beneficial.

Proposed Key Functional Requirements

- Mobile device connects to the MTG of the tractor via bluetooth to setup wireless and downloads machine data securely to the mobile device and stores in on the cloud.
- Augmented Reality View: allows the user to take of picture of their vehicle which will then show machine information and overlay buttons on the vehicle. These buttons will then provide more information of that status of the vehicle.
- Maintenance Information and Alerts: provides information on the maintenance state of the tractor and will display alerts when machine vitals pass predefined thresholds.
- The application will work in the following 2 modes:
  - Farmer Mode—provides all the features listed above.
  - Dealer Mode—provides all the features of the farmer mode and in addition this mode will allow a dealer to quickly sort, classify, tag, and search for vehicles he has registered on his app.

Project Statement

The current situation is that the John Deere API allows the individual to have access to some maintenance machine information of their tractors. This is done by connecting to John Deere's servers in order to view the information. The problem that arises from this implementation is that the farmer may not be able to connect to a network while working in the field. To bridge this gap our group proposes an iPhone app that allows the farmer to directly connect to their machine through wireless. The application would then allow the user to gain key knowledge of their machine by providing them with alerts, service information, and great visuals. This application will sustain a similar theme to other John Deere apps such that it makes the experience for the user more familiar and easier to use. Giving the farmer vehicle information on the mobile device with the machine health information overlaid right on top of their vehicle, makes their job quicker and simpler so they can get back to work as fast as possible. The application will have two different types of users: farmers and dealers.

What Value Does the Project Offers

Our project is designed for the owners of John Deere tractors in order to give them an easy resource to gain information and know the status of their vehicle. In a sense our project is designed to be a one stop shop for the farmer so that they have access to all of their vehicle's health information in one place. Through the use of image recognition and augmented reality software our application provides the user with a quick, interactive way of displaying the vehicle's information by just having the user simply take a picture of their vehicle. The design of this application will provide developers with information of the tractor through the use of log files. These log files will be logged to the MyJohnDeere API and be available to developers. Vehicle dealers are intended to benefit from having a convenient method to look up, sort, get alerts, and quickly display information about vehicles they have registered

Is this Project Feasible

Given our resources and schedule this project is definitely feasible. Last year's project team completed a lot of the major functionality and provided us with a great base. Much of the required data is available through John Deere's developer API and the constant connection with their tractors. Our team will not have to make any changes in hardware and will be focused mainly on communication, user interface, and a robust augmented reality component. Mobile applications are extremely powerful and common, which means the support for developers is great. More specifically the resources for Apple iOS development are large and will become extremely beneficial.

System Design

System Requirements

Component	Description
System 1	iOS devices with iOS 7+
System 2	Yukon MTG Low Energy Bluetooth Capability (client provided)
Xcode	Version 7+ Apple's iOS development Platform
MyJohnDeere	Cloud services provided by client API
Wikitude	Augmented Reality and image recognition software (free trial)
Vuforia	Augmented Reality and image recognition software (free)
Bluetooth Connection	Establish connection securely with Yukon through Bluetooth
Bonjour	Establish Wi-Fi connectivity
UI	User interface specific to fit client and user needs
AR UI	Augmented reality to provided user with easy point and shoot capability

Table 1

Our Project will rely heavily on John Deere's MTG or Modular Telematics Gateway, as shown below. This hardware is the core of our project. The device is embedded in the John Deere vehicles that our application connects to. The MTG is equipped with low energy Bluetooth and an on board Wi-Fi chip. In addition this device gathers all of the important vehicle health information that will be sent to the mobile app. To find out more information about the MTG follow this link: https://www.deere.com/common/docs/products/equipment/telematics/brochure/john_deere_mtg.pdf

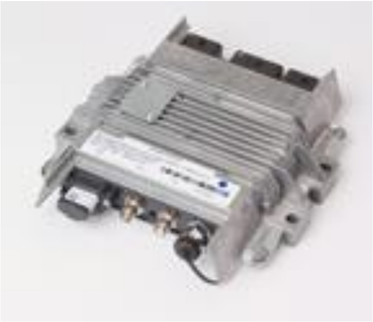


Figure 1

Functional Decomposition

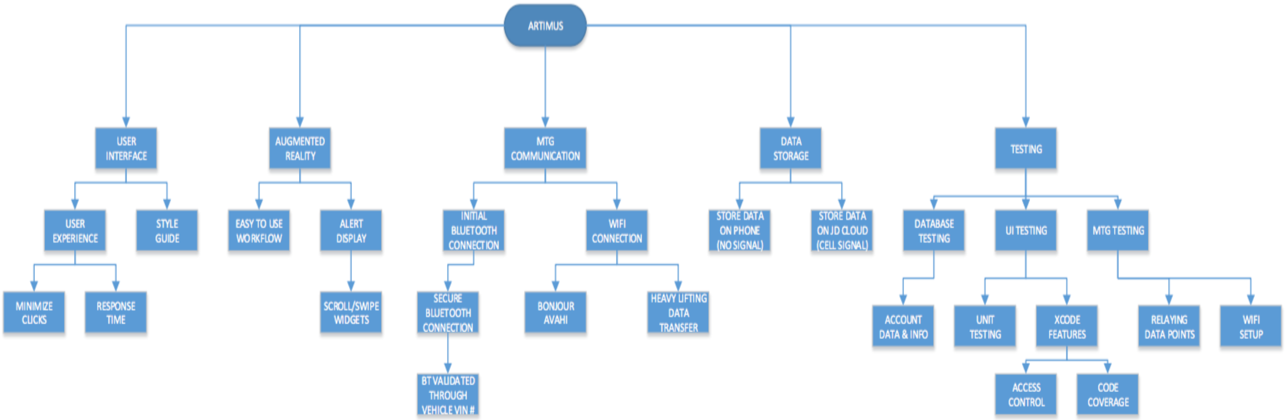


Figure 2

If image is too small go here http://may1609.sd.ece.iastate.edu/uploads/treeDiagram.jpg

Overall Project Completion Chart

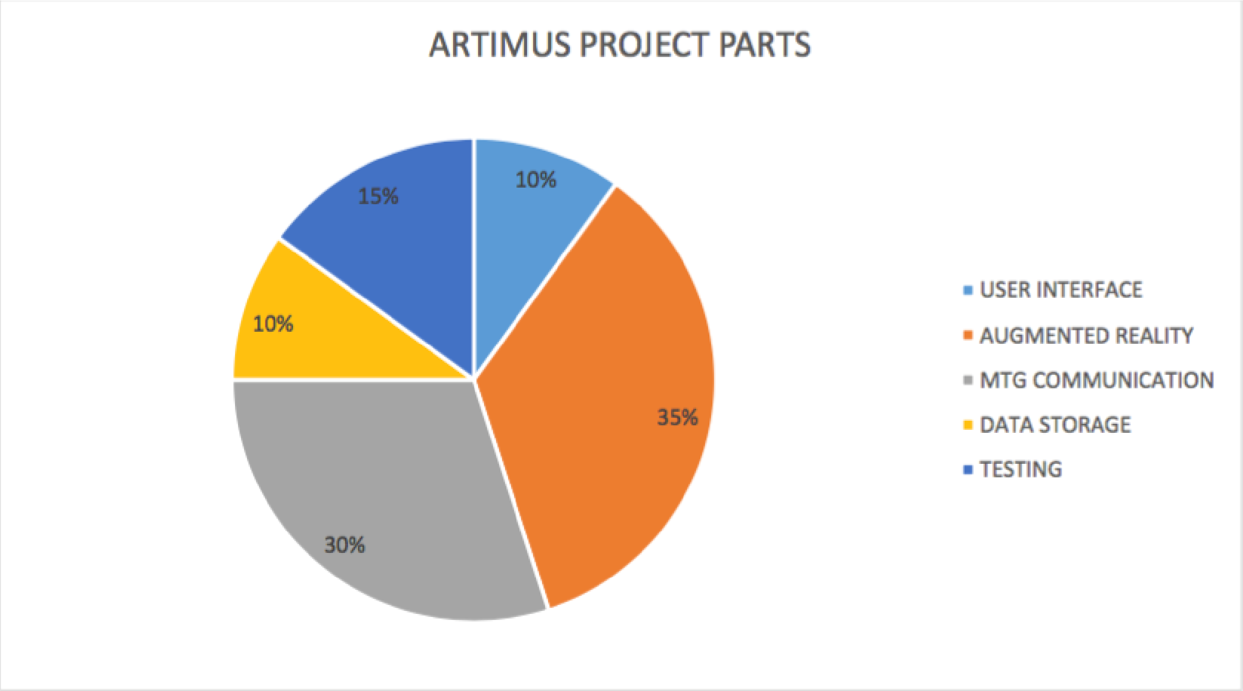


Figure 3

System Analysis

This project is comprised of the following pieces and resources:

Wikitude Augmented Reality SDK

Our team will be using the Wikitude library to handle the image recognition, and augmented reality experience of the application. This will replace the Vuforia SDK that was used in the first iteration of this application. Wikitude provides far more robust image recognition, and is well documented and tested for iOS devices, the target device of our project.

Xcode iOS Development

The Xcode IDE provides all the tools necessary for developing iOS applications. An especially useful tool for our team will be the Interface Builder, which will be used to design the application's user interface to match John Deere design standards.

External APIs

Communication with each tractor's onboard MTG will involve the use of John Deere APIs, which are maintained and supported by the Intelligent Solutions Group. There are no anticipated issues with those.

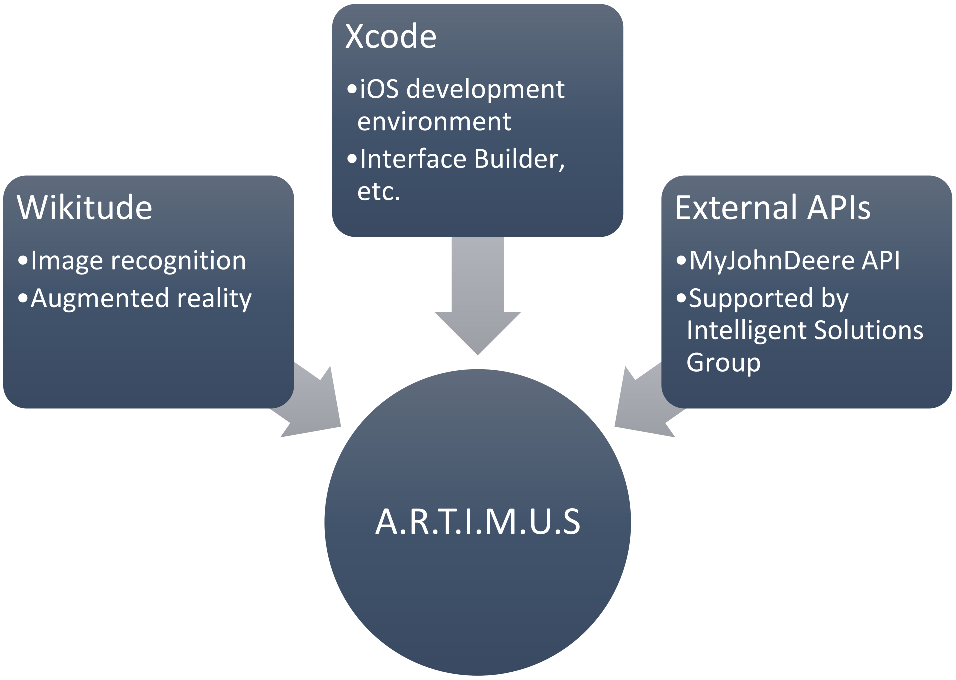


Figure 5

System Block Diagram

Currently data is being stored on the mobile device itself and we are looking to store all of the data on John Deere's cloud component instead. Also the current MTG version does not have an on board WiFi chip however the newest one will (expected in about 3 months).

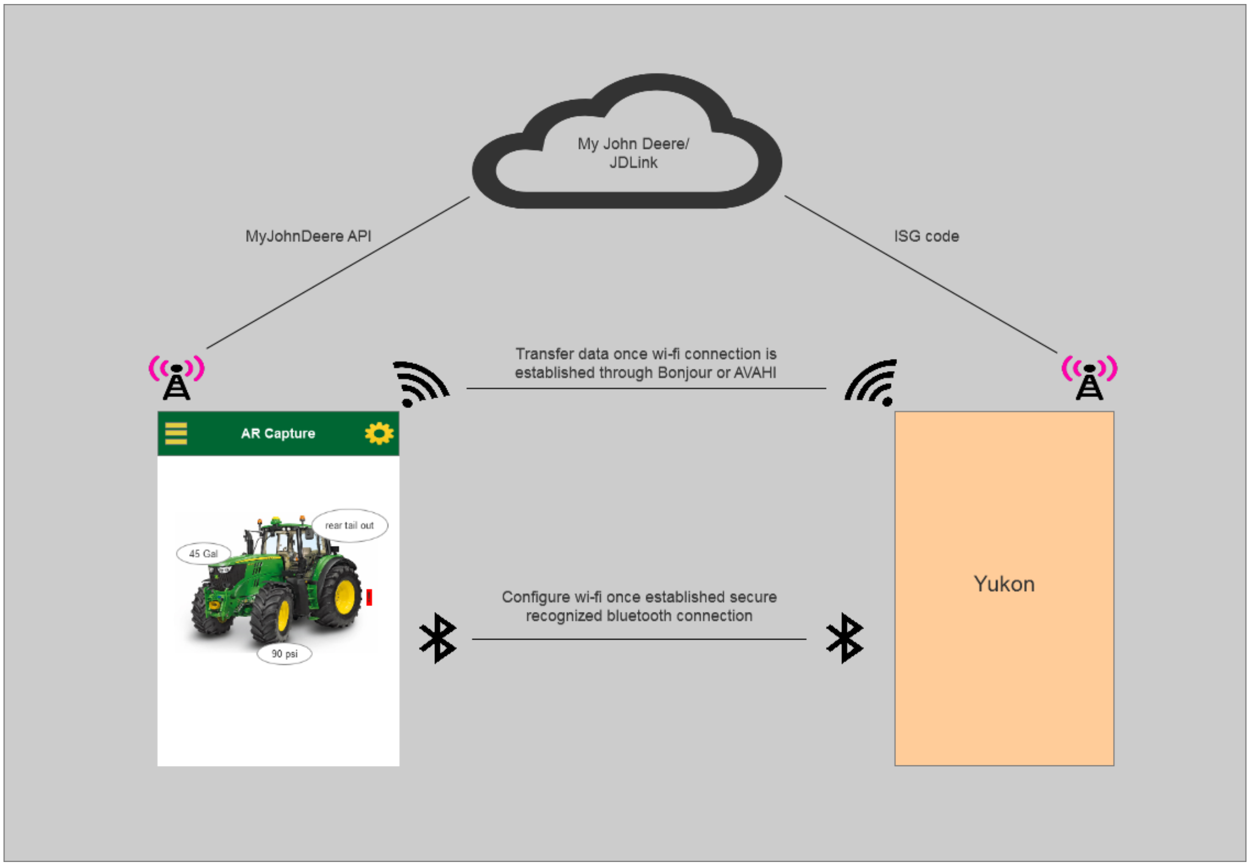

My John Deere/
JDLink
MyJohnDeere API
ISG code
Transfer data once wi-fi connection is established through Bonjour or AVAHI
AR Capture
rear tail out
45 Gal
90 psi
Configure wi-fi once established secure recognized bluetooth connection
Yukon

Figure 6

Application Block Diagram

Our application makes use of the Apple iOS navigation stack, which provides the user with a familiar and natural user interface. Our design standards are meant to comply with John Deere and Apple.

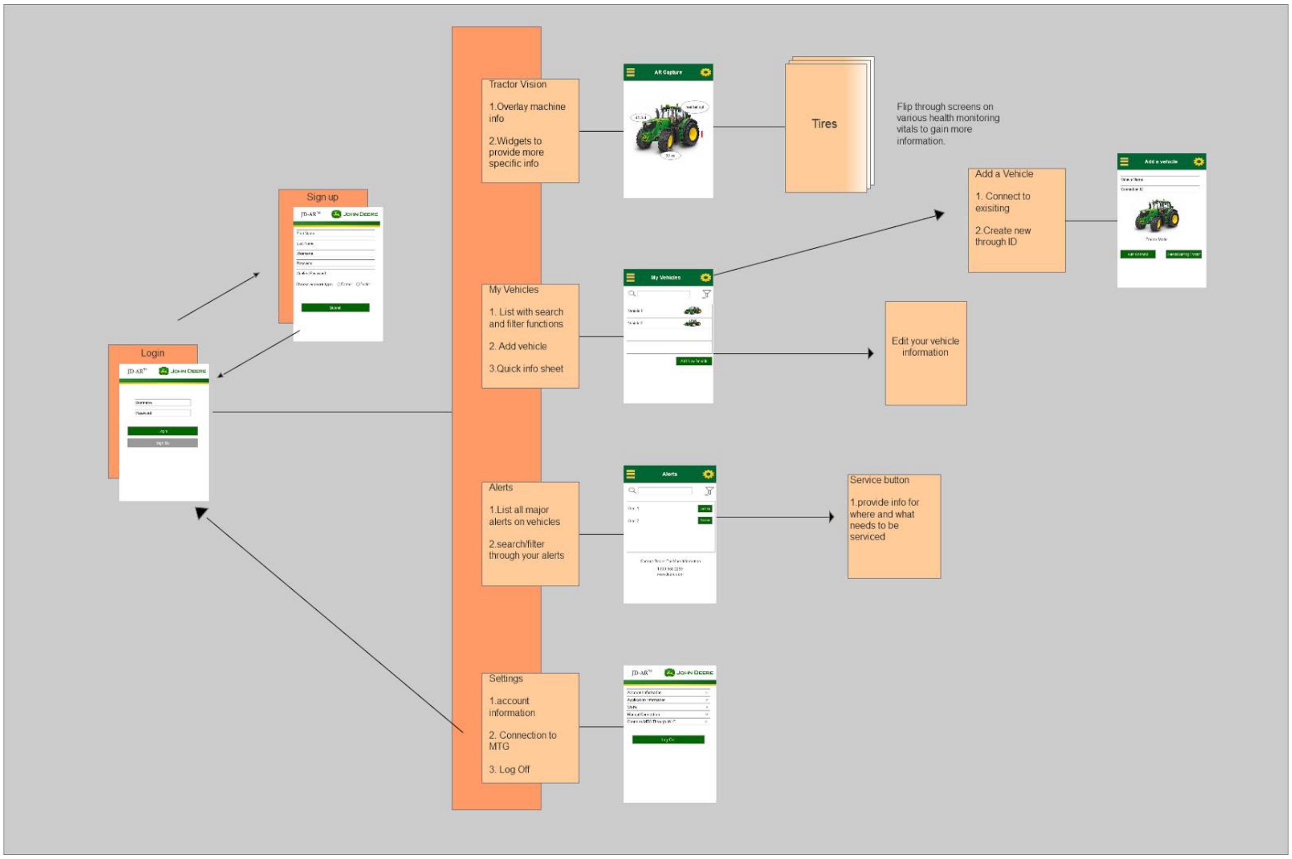

Tractor Vision
1.Overlay machine info
2.Widgets to provide more specific info
AR Capture
Tires
Flip through screens on various health monitoring vitals to gain more information.
Sign up
Login
My Vehicles
1. List with search and filter functions
2. Add vehicle
3.Quick info sheet
My Vehicles
Add a Vehicle
1. Connect to exisiting
2.Create new through ID
Add a vehicle
Edit your vehicle information
Alerts
1.List all major alerts on vehicles
2.search/filter through your alerts
Alerts
Service button
1.provide info for where and what needs to be serviced
Settings
1.account information
2. Connection to MTG
3. Log Off
JD-AR™
JOHN DEERE

Figure 7

Detail Description

I/O Specification

A user's iPhone device communicates with a device on board the tractor called an MTG. The phone will use Bluetooth and wireless to transmit and receive data.

In order to identify and connect to a machine Bluetooth is used to probe for available vehicles to connect to. Based on the received information, the user can connect to the MTG and continue to set up a Wi-Fi connection to handle the data intensive transfers. The functions and services on the MTG will be provided by ISG through TCP requests through Wi-Fi.

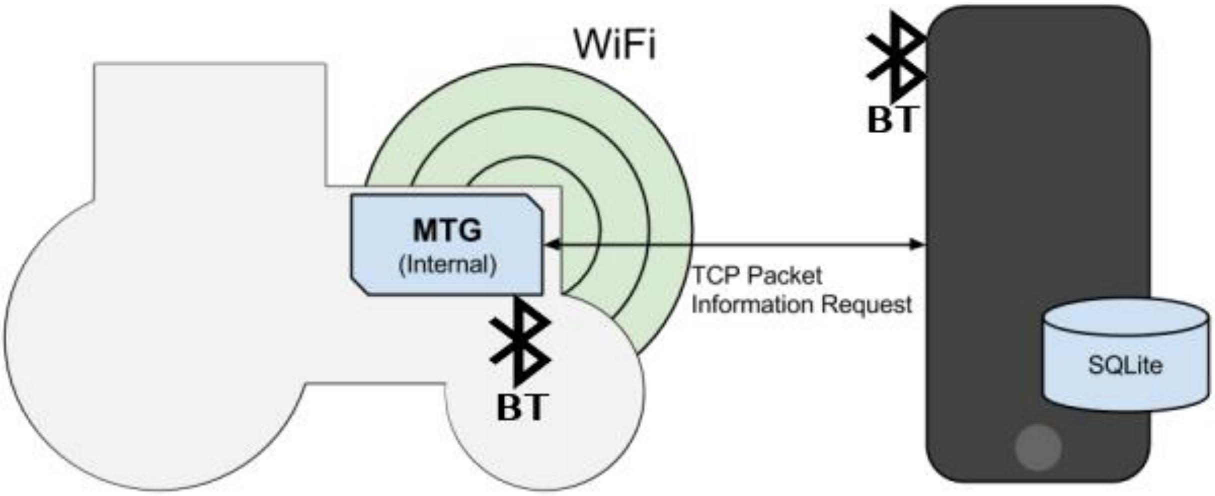


Figure 8

The application will also use the camera on the device to capture the tractor. The camera features are to be handled through Apple camera framework provided with the iOS SDK.

For the use of some frameworks and libraries, such as the Wikitude Augmented Reality library, some additional requirements may be needed.

User Interface Specifications

Login and Signup

After the application loads the user will be first presented with the login screen. The user will have to create an account before entering the application.

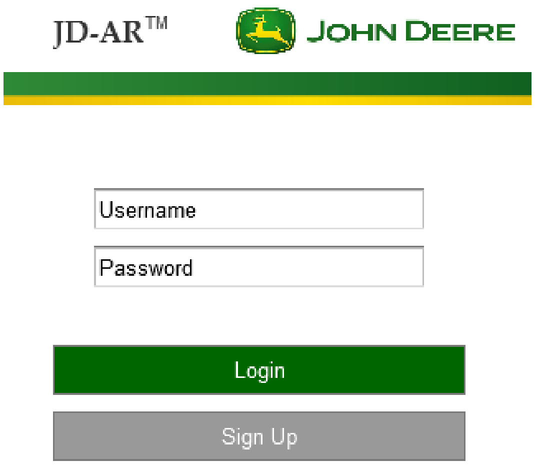


Figure 9

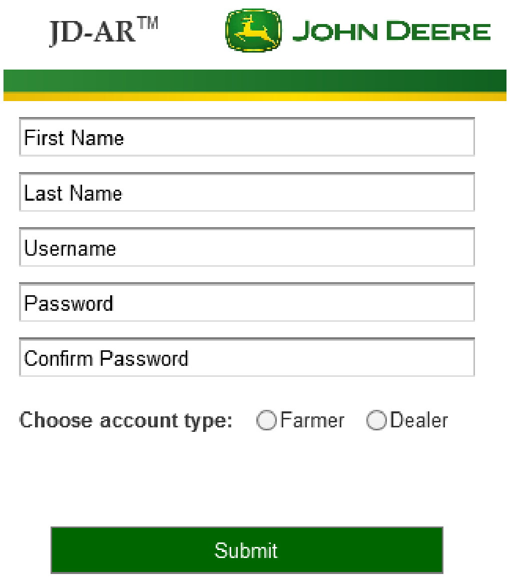


Figure 10

The user will input the information shown above with some password constraints. The password constraints are 6-10 characters with one numerical, and capital letter. Upon creating the account the user will receive a notification showing that their account has been successfully created and then they can login.

My Vehicles

The user can then navigate to the my vehicles page once they have successfully logged in. This is the default home screen. Here the user can see their vehicles in a list view and search throughout the list based on some standard filters or by name. Those filters will include: date and type. Within the my vehicles page the user can also create a new entry if they choose.

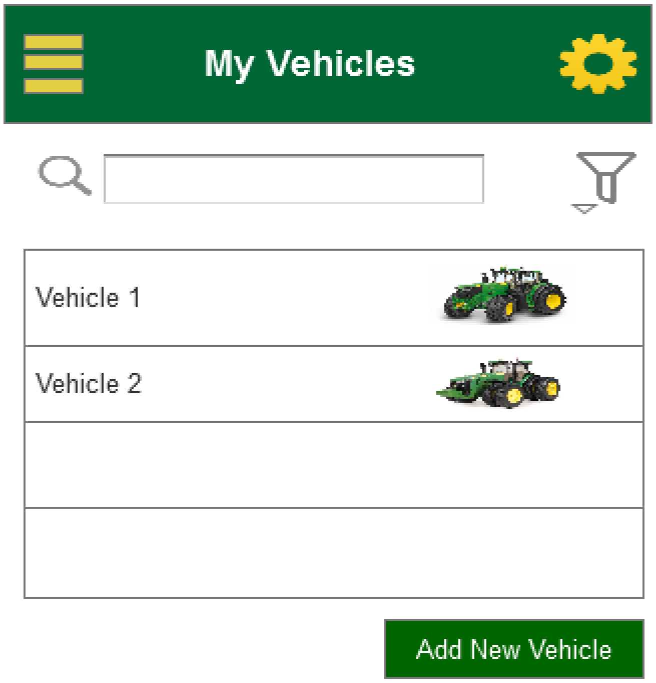


Figure 11

Add Vehicle

This page provides the user with a few ways to connect to a vehicle and add it to their list. The first way is to use the auto connect button which will use the connection ID if inputted to connect to the tractor. The other way to connect is to connect to network provided by the TPLink device.

Once connected you'll need to select the appropriate IP address. Click on the Settings tab and then on the 'Manual Connection' option. In the fields provided enter the appropriate IP addresses. If using the simple server you will enter the IP of the computer running the server and the port will be 4444. If using the MTG the IP will be 172.16.0.2 and the port will be 45544.

Finally you can return to the My Vehicles page and choose 'Connect' for your vehicle. You will be asked if you are connected to the appropriate network, choose the option that indicates you are to continue.

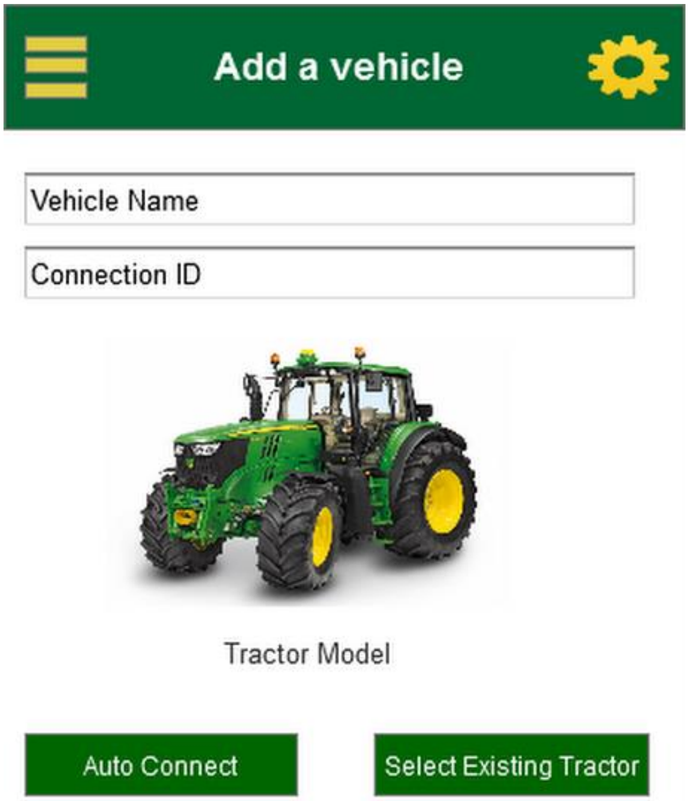


Figure 12

Settings

The settings page can be accessed by selecting the settings icon in the upper right corner of the screen. From here the user has the option to see account and application information along with connection information.

The connection information is designed to provide the user with easy instruction on how to connect to their vehicle through the MTG.

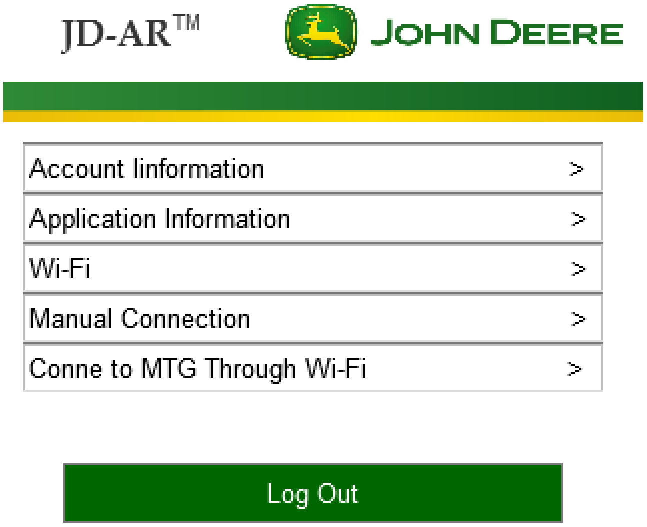
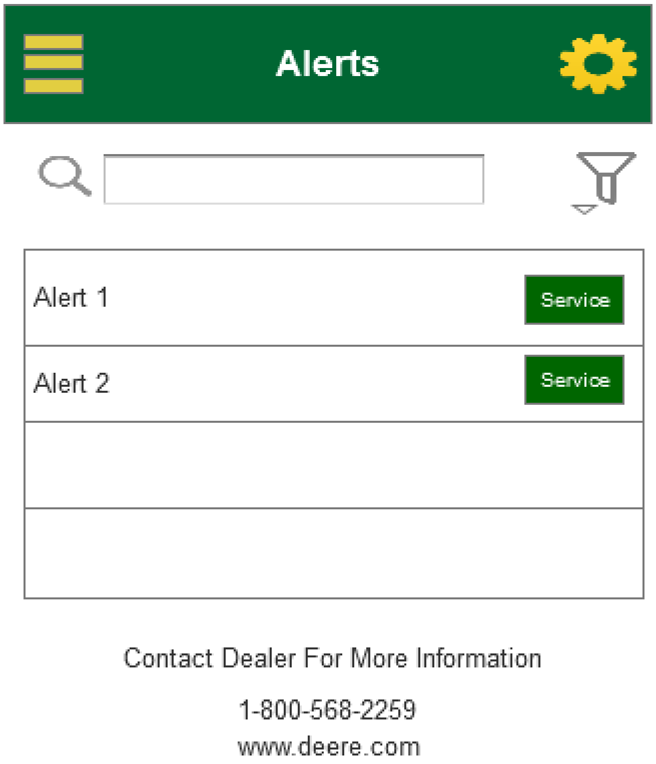


Figure 13

Alerts

The alerts page provides the user with a list view of all major machine health alerts of all their vehicles. The user can search through these alerts by filtering them based on category, importance, and date. From there the user can also click on the service button to brought to John Deere's website for maintenance scheduling.



Contact Dealer For More Information

1-800-568-2259
www.deere.com

Figure 14

Augmented Reality

The augmented reality capture screen allows the user to take a picture of their vehicle and in turn see machine information being overlayed on top of their vehicle. From there the augmentation will allow the user to navigate through widgets for more information about the status of their vehicle.

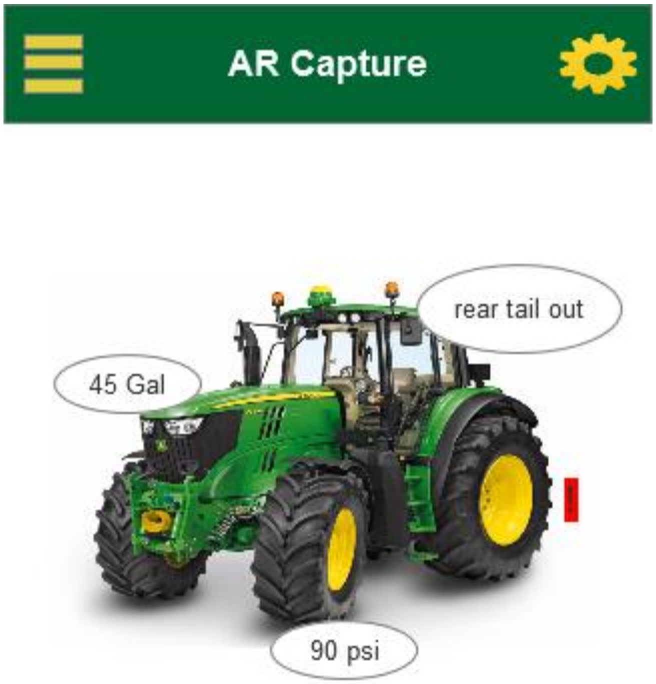


Figure 15

Use Cases

Use Case 1: Login

Primary actor: application user

Preconditions: the application has been launched successfully

Basic Flow:
The user launches the application, sees the splash screen, and then continues to the login screen. The user reaches the login screen and enters their credentials. The user is validated and saved through MyJohnDeere and is navigated to their home screen.

Alternative flow 1: Signup
The user cannot login because they haven't created an account. The user chooses the signup button and then is brought to the signup screen. The user has to enter first, last, email, and password. Password requirements are 6-10 characters with one number and a capital letter. If the password requirements are not met the signup process doesn't complete and an alert pops up stating the password requirements aren't met.

Alternative flow 2: Login fails
The user launches the application,sees the splash screen, and then continues to the login screen. They enter their credentials and an alert pops up stating that their username or password is incorrect.

Alternative flow 3: Still logged in
The user launches the application, sees the splash screen, and then instead of being brought to the login screen the user is brought to the last screen they were currently on in their session. The session timeout for this will be 1 hour.

Use Case 2: Vehicles (Home Screen)

Primary actor: application user

Preconditions: the application has been launched successfully and the user logged in.

Basic Flow:
The user has completed the preconditions and will be brought immediately to their vehicles screen. This screen shows all of the users vehicles in the form of a list view.

Alternative flow 1: Add vehicle
The user has completed the login process and selects the plus icon from their their vehicles (home) screen to add a new vehicle. The user is then brought to the add vehicle screen.

Alternative flow 2: Connect to current vehicle

The user has completed the login process and selects the connect button from one of their previously added vehicles in the list. The user will be prompted with a success or failure alert upon choosing connect.

Use Case 3: Add Vehicle

Primary actor: application user

Preconditions: the application has been launched successfully and the user logged in. The user selects the plus icon from their home screen to add a new vehicle.

Basic Flow:
The user has completed the preconditions and will be brought to the add vehicle screen.The user can input a vehicle's name or the connection ID from which they are already accustomed to knowing. From there they select the tractor by clicking on the choose tractor button which will show all of the possible vehicles.

Alternative flow 1: User selects connect button
The Application will attempt to connect to connect the tractor via TCP connection over wireless. If successful an alert will be shown and connect will be disabled, if not successful an alert will be shown and button will still be enabled.

Use Case 4: Augmented Reality

Primary actor: application user

Preconditions: the application has been launched successfully and the user logged in. The user selects the tractor vision icon from their home screen menu.

Basic Flow:
The user has completed the preconditions and will be brought to the tractor vision screen. The user is provided with a camera view of their surroundings ready to capture an image. The user snaps a picture and is presented with their augmented view of their vehicle.

Alternative flow 1: User selects a widget
Upon snapping the picture of the vehicle the user selects a widget of some machine information displayed. The user is brought to a new screen with tabs where they can see more information on the status of their vehicle. They can continue swiping horizontally to go through all of the widgets for that vehicle.

Use Case 5: Alerts

Primary actor: application user

Preconditions: the application has been launched successfully and the user logged in. The user selects the settings icon from their home screen.

Basic Flow:
The user has completed the preconditions and will be brought to the alerts screen. All alert information on all of the users vehicles will be displayed. The user can search through each alert to gain more information on how to service the issue for their vehicle.

Alternative flow 1: User selects service
The user will be brought to a new screen specific to the alert they selected. Based on the type of the alert the user will be provided with options and guidance for how to contact John Deere about the issue or service the vehicle themselves.

Use Case 6: Settings

Primary actor: application user

Preconditions: the application has been launched successfully and the user logged in. The user selects the settings icon from their home screen.

Basic Flow:
The user has completed the preconditions and will be brought to the settings screen. The user will be provided with a list of settings options and a logout option.

Alternative flow 1: User selects account information
The user will be brought to a new screen displaying their account information that is saved in MyJohnDeere.

Alternative flow 2: User selects application information
The user will be brought to a new screen with application information: version, date modified, creator.

Alternative flow 3: User selects logout
The user’s session will expire and they will be brought back to the login screen.

Use Case 7: Bluetooth Connection to MTG

Primary actor: application user

Preconditions: the application has been launched successfully and the user logged in. The user selects the connect to tractor via bluetooth from the home screen.

Basic Flow:
The user has completed the preconditions and will be brought to the bluetooth screen. The user will have directions displayed on how to pair with their tractor. A successful pair will happen if the device name shows up correctly as the user expected.

Alternative flow 1: User pairs unsuccessfully
The user will see an alert that pops up showing that there was no device paired. From here the user can try pairing again or navigate to somewhere else in the application.

Alternative flow 2: User pairs with incorrect device
The user will pair with a device but then see an incorrect device name. The user will click on the button to unpair the device and retry to pair with their correct device.

Hardware/Software Specifications

Hardware Specifications

Mobile Device

The application will only support Apple iPhone devices running the supported iOS version. See the following links for specifications for each device.

- □ iPhone 4: https://support.apple.com/kb/SP587
- □ iPhone 4s: https://support.apple.com/kb/SP643
- □ iPhone 5: https://support.apple.com/kb/SP655
- □ iPhone 5s: https://support.apple.com/kb/SP685
- □ iPhone 6: https://support.apple.com/kb/SP705
- □ iPhone 6s: http://www.apple.com/in/iphone-6s/specs/

MTG

The MTG supports WiFi and Bluetooth. Full specifications are not available.

Software Specifications

The application currently uses iOS 7 and Vuforia. The application will replace Vuforia with Wikitude for augmented reality.

Interface Specifications

The application does not have an external API. The internal API is currently unchanged from Phase I.

John Deere

The application will use the John Deere API for login and integration with John Deere's cloud service, MyJohnDeere. See the following link for the full API.

https://developer.deere.com/

Vuforia

The applications currently uses Vuforia for Augmented Reality. See the following link for the full API.

https://developer.vuforia.com/

Wikitude

The application will use Wikitude for Augmented Reality. See the following link for the full API.

http://www.wikitude.com/documentation/

MTG

The application will communicate with the MTG. Details on the API are not currently available.

Simulations and Modeling

- By come end of the first semester we hope to have Bluetooth communication working and integrated into the previous team's app
    - In addition to this we will hope to also show a new and improved user interface that is more tailored to John Deere's style guide a features
- Additionally monthly demonstrations will show progress for the application throughout.
- Regular monthly check-ins with John Deere will provide quick feedback to assist in our iterative development life cycles
- Our iOS mobile app will not be available on the app store, the apps location will be local and be able to be downloaded onto group members iPhone's for testing and usability protocols

Implementation Issues and Challenges

Based on our requirements we believe our project has great potential for a good, finished product. Currently we already have major application functionality working thanks to the previous project team and we know how to move forward. Given our resources and knowledge the additional requirements we are asked to do can be done in the allotted time. Some concerns however arise with the timeline on when the new Yukon MTG will be completed with the low energy Bluetooth. We will be able to develop and test this without the actual MTG however problems may arise when put in place with the actual device. In addition the augmented reality portion of this application might not be what our client and our group hopes it to be. This is due to the augmented reality software being a new technology and not quite meant for our situation. Here is a table that better illustrates all of the issues and challenges of our project solution:

Issue/Challenge	Evaluation
Bluetooth communication	There are currently some challenges and unknowns with the Bluetooth communication. iOS Bluetooth communication is one-way and there needs to be a standard for how our team will send data with John Deere's MTG. See appendix A. This can be through the creation of a GATT (generic attribute) Bluetooth profile or some easy work arounds through storing vehicle information on a file in a specific location.
Validation of user before pairing device	Upon the MTG sending information back to the user, the user will have a decision to pair with the MTG given the information they received. We just don't want anyone to be able to connect to the MTG, so we would want the user to enter a password of some form if they wished to pair their device with the MTG. The issue is that the scope of this project is designed when there's no cell signal. Ideally we would want to match the password they enter with a MyJohnDeere password, but we would be unable to process that request.
Augmented Reality software	For this project phase 1's group was unable to provide John Deere with a working augmented reality aspect for this application. Their augmented reality could only recognize small toy tractors. Our group has been looking at a new augmented reality software, Wikitude, in comparison to last year's choice of Vuforia to achieve better results.
Data storage	Last year's project phase 1 team managed to store all machine and account information on the mobile device. We are looking into doing the same thing with some additions. Initially we would want to store all of this data on the phone because there would be no cell signal, however once cell signal is available we want to transfer this data to MyJohnDeere's cloud services.

Table 2

Test Plan

Unit Testing

Access Control

In Xcode 7 you can develop with the new swift 2 language instead of objective C. Swift 2 brings some new great ways to unit test. The first is in access control. This is done by using the @testable attribute the unit test target has access to every internal entity of another module in the project. The @testable attribute allows some basic unit testing practices like the assertEqual function.

Code Coverage

There is also another great feature for testing that comes with the new Xcode 7 version- code coverage. This process is done by some simple configuration in the Xcode scheme settings and it allows the developer to run all of their unit tests throughout the workspace at once and view the results. From there the developer can click on the individual unit test case and go straight to the source code to see how many times the test was called and the4 number of successes or failures occurred. This in combination with access control make unit testing pretty simple in Xcode.

UI Testing

There has never been a great, built in way to test the UI in the past versions of Xcode, thankfully that has changed. The process is an expansion on Apples XCTest framework through adding three classes: XCUIApplication, XCUIElement, and XCUIElementQuery. UI testing is only available for iOS 9+. Testing the UI in addition to the unit test will cover a lot of ground for testing our application.

Testing Process

Our testing process will be carried out in three major ways: testing the database entries, unit testing, and communication testing with the MTG.

Database Testing

1. When a user account is created check the database
2. When a user adds a new vehicle check the database
3. When a user is logged out make sure the session variable is false
4. When an alert happens on a vehicle make sure the alert is stored

Unit Testing

1. Check major components of UI to make sure updating is correct
2. Check logic within the models to make sure variables are correct
3. Check that the view controllers are navigating properly

MTG Testing

1. Make sure bluetooth connection has correct name when paired
    a. Includes correct VIN and model number
2. Test the wi-fi setup connect
3. Make sure MTG is relaying all of the data points to the mobile device

Validation and Acceptance Test

Reliability

The reliability aspect of our validation and acceptance will be a combination of our testing plan in pair with other reliability testing. The first reliability testing will take place when the phone has access to cell service to see if the data is transferred to MyJohnDeere properly and how long that process takes. Other testing will be done with the MTG communication. We will test to make sure that the MTG will always be able to woken up via bluetooth and that the wireless is set up accordingly. We will also test to see exactly how far away the user can be from the vehicle to remain connected to the MTG.

Scalability

There isn't much we can do for a scalability test for our project. The only we see fit for this is to have the user perform a high number of tasks such as adding a lot of vehicles to see how the system reacts. This scenario relates more towards the application operating in dealer mode having a large number of vehicles on their account.

Usability

Our usability testing will be done through validating that our use cases our functioning properly. This means that based on the action done by the user that they're being presented with the proper screen, information, and dialogue. In addition we will check that the customer is okay with the UI as far as functionality, look, and feel.

Security

Our procedure for secure will be to demonstrate this to the customer directly. This will be done to show that the user can only connect to their added vehicles and they won't accidently or purposely connect to another's vehicle.

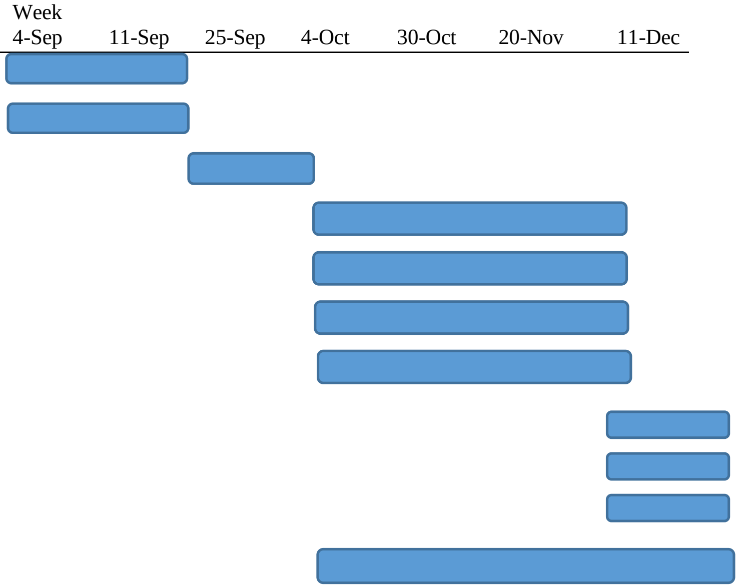
Maintainability and Configurability

We will leave this up to the customer on how they will provide security patches or updates for the application. The configurability aspect will be validated by demonstration on how the customer can modify the application to better suit their needs in the future.

Software Design

Software Design Schedule

Activity	Start	Duration
Understand Phase I	4-Sep	7
Requirements	4-Sep	7
Design	11-Sep	7
Bluetooth	4-Oct	21
Wi-Fi	4-Oct	21
User Interface	4-Oct	35
Data storage	4-Oct	35
Augmented Reality	11-Dec	35
MTG Communication	11-Dec	35
Integration with Bonjour	11-Dec	35
Testing	4-Oct	56



Conclusion

This project is going rely heavily on the communication with the MTG, thus this is our main focus to get the application running efficiently. Next our focus is on the augmented reality workflow and design. Our goal is to make the app as easy for the user as possible, however given that augmented reality software today isn't still super robust we may have to be creative in how we incorporate it into our project. Through our documentation we believe we have a great base plan to continue and modify development for this application. All of the resources for this project are accounted for, and at the moment we do not think there will be any additional resources needed to start development. Based on our extensive research and meetings we believe to have some great ideas for the augmented reality and improved MTG connection portions for this project.

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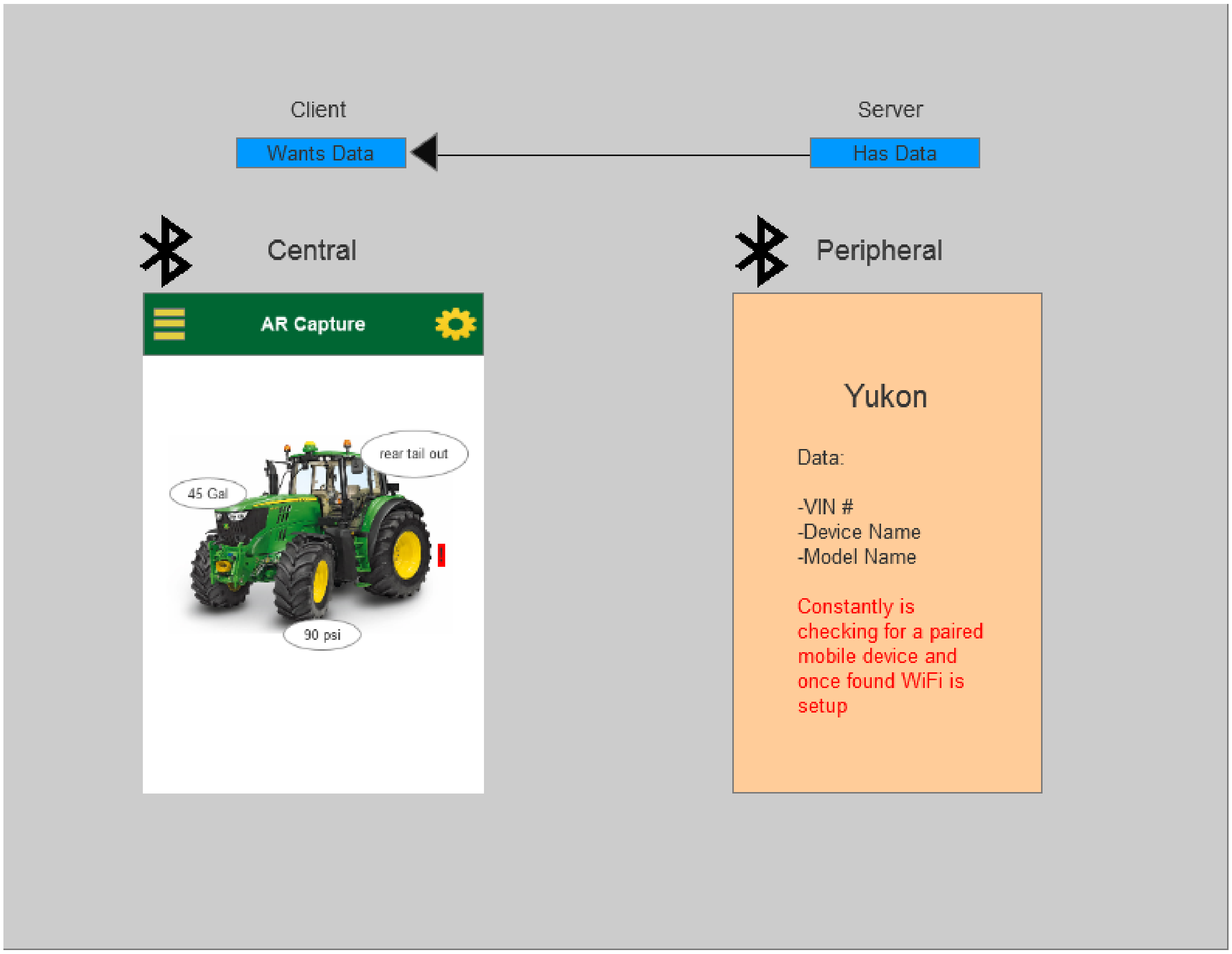
"Telematics and Work." (1994): Web. <https://www.deere.com/common/docs/products/equipment/telematics/brochure/john_deere_mtg.pdf>.

Appendix A



Yukon

Data:

-VIN #
-Device Name
-Model Name

Constantly is checking for a paired mobile device and once found WiFi is setup