Fall 12-9-2022

American Football Strategy and Tactics

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AFST

AMERICAN FOOTBALL

STRATEGY AND TACTICS | CAPSTONE PROJECT
HONOURS BACHELOR OF COMPUTER SCIENCE (MOBILE COMPUTING)

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ABSTRACT

The difficulty in visualization of the game of football has made it problematic to create a football strategy and hard to coordinate it with others as coaching is not modernized. The majority of people do not realize that football is a complex strategic and tactical game. An augmentation of this process, using mixed reality and mobility to improve the experience will show football in a new light to allow for new collaborations and various new plays that will take the game to a whole new level. There is no current solution for the average football coach. Coaches watch a game and work on their game strategy with whiteboards or tablets, but it can be hard to visualize the game of war happening behind the scenes between the teams of coaches and coordinators on both teams beyond the individual players.

ABOUT CAPSTONE PROJECTS

TIMELINES • PROGRAM • SCHOOL

- **September 2021 – December 2021**: Capstone Project Inception, 4-credit course (18 hours / week)
- **September 2022 – December 2022**: Capstone Project, 4-credit course (18 hours / week)

PROGRAM • SCHOOL

- Hons. Bachelor of Appl. Computer Science (Mobile Computing)
- Applied Computing, Faculty of Applied Science and Technology

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Table of Contents

INTRODUCTION

This is the Virtual Playbook project document, containing Project overview, Project Requirements, Project Architecture, Project Plan, Validation and Testing, Conclusion and Bibliography.

PROJECT OVERVIEW

The Virtual Playbook will use mixed reality to aid football coaches and players to visualize complex plays so they can enhance the way football is played. Our team consists of Max Komor the project owner, Mike Komor the SCRUM master and Muhammad Mooraja the risk analyst. The industries related to this project, the problem to be solved, and the solution that will be created during this project can be found below.

DOMAIN AND INDUSTRY OVERVIEW

This project falls under the NFL as the main stakeholders are coaches from professional teams. In 2021, the combined value of the NFL was $111.48 billion across its 32 franchises with a yearly revenue of about $12.2 billion. Enhancing the preparation for the game of football and introducing more complex and intricate strategies will help the coaches instruct the players making the game more enjoyable and competitive, which will in turn create more interest in the game and bring the game to its next stage of evolution.

PROBLEM DESCRIPTION

Currently football coaches use whiteboards, clipboards or just paper to create plays and game strategies, however, that is a disadvantageous position for coaches and players to be in. This is because football is a complex game with many moving pieces and in its current state the plays and strategies are limited, since there are not any better ways of conveying these plays from coaches to players. There is no current solution for the average football coach. The average coach watches a game and works on the strategy with whiteboards or tablets, but it can be hard to see the game of war happening behind the scenes between the teams of coaches and coordinators on both teams beyond the individual players.

This is a problem worth solving because it is a major limiting factor for many people learning about football, coaching football as effectively as possible and fans enjoying a better quality of football. Football is a game that at the high level seems rough, rugged, and more of a game of physicality than one of strategy. But as one learns more or is shown this additional layer, they realize physicality is just one aspect and it truly is more a game of strategy and tactics.

SOLUTION DESCRIPTION

The impact will be incredibly significant to how people see the game. Simply put, this product will revolutionize how football strategy and tactics can be developed for American football. It will allow coaches, coordinators, players, and

overall football teams to see the game at a whole new level of depth, both figuratively and literally. Overall, this project is feasible to implement. Creating an AR application that will augment the visualization of plays through a 3D viewing environment for players to view and study plays that coaches have created via the editing functionality of a separate iOS application to usher in the next generation of masterfully crafted plays.

Mobile Computing

An iOS application to be used by the coaches that allows them to create new plays and edit existing plays that will be saved to the cloud. Using an iOS application for iPhones and iPads for easy editing and convenience, which will help the stakeholders.

Cloud Computing

The project will use cloud computing backend to support the application with relevant player/team data and analytics as a backend solution.

Advanced Areas of Computer Science

Mixed Reality. Use of Augmented Reality for viewing the application through HoloLens. This application is created in AR using Microsoft HoloLens 2 and Unity. AR is pivotal and the major concept of the idea.

Simulation and Visualization. The mixed reality application will provide a new 3D visualization of football strategy and tactics and after a play is created will move to simulate how it will go. This will simply take the learning and immersion to an entirely new level as the coaches and players can see how the play will play out.

SOLUTION IMPACT

This solution would have an enormous impact on the football coaching experience as it is aimed at and explained previously. Additionally, for players being able to see the plays of the game in AR will augment their learning experience. Simply put, this will revolutionize how strategy and tactics in football are developed.

SOLUTION FEASIBILITY

In this subsection, the feasibility of the project is analyzed with Technical Design and Construction in mind, alongside deployment, and adoption of our application.

Design and Construction

From a technical standpoint, in terms of the iOS application, creating an editing environment where coaches can move objects representing players and construct lines to display routes and add additional information to the plays that will be saved to the database is quite feasible for an iOS application. In terms of the HoloLens 2 application, the primary goal is to retrieve plays created in the iOS application from the cloud and display them in the AR space and simulate the movements of the players. Using Unity and HoloLens 2 capabilities, this solution is feasible according to

the research gathered by the team and the discussion with our AR domain expert. There is a risk of potentially improper design or mistakes in the design process that we need to be aware of so that they do not occur given the team's inexperience in developing a Mixed Reality Application.

Deployment

For a community partner like a high school team the deployment may not be very feasible due to the cost of a HoloLens. For a larger institution like a college football team or furthermore a professional team playing in the NFL this would not be an issue and it would be very feasible to implement.

Adoption

Adoption on concept alone may initially not be exceedingly high. However, the team is confident that with some demonstration and given that the UI will be easy to use and navigate there will be a major shift very quickly which will lead to greater adoption.

PROJECT REQUIREMENTS

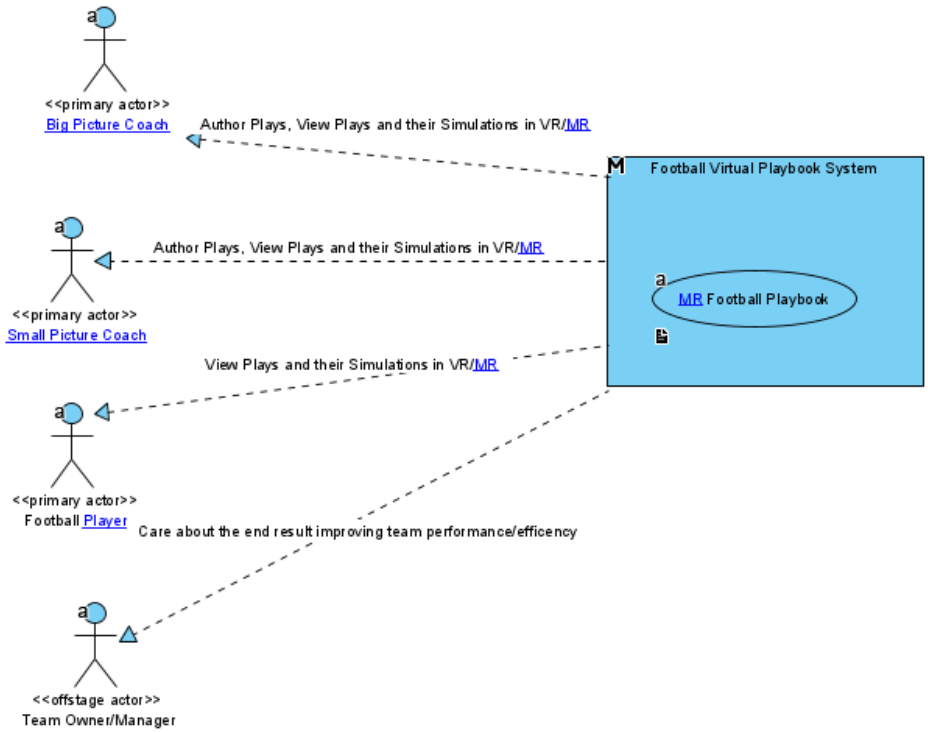
In this section, the primary goal of the system is analyzed, along with who the system is intended to cater towards, and some UI design examples are explored. In contrast to the Project Architecture section, this section looks at the concept on a higher and more real-world level (why we are doing this and a bit of how it will look like) vs. a lower and more technical level (more the how we are going to do this).

Visual Paradigm Link: https://online.visual-paradigm.com/w/wleigogf/diagrams/#diagram:workspace=wleigogf&proj=3&id=5

SYSTEM CONTEXT

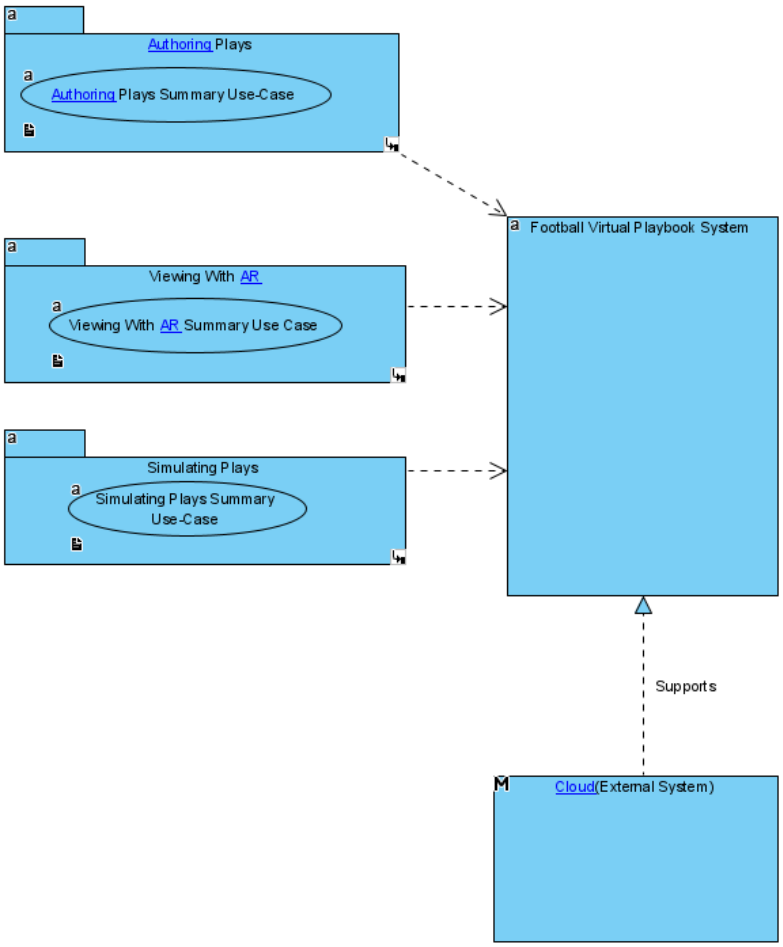
The primary actors of the system are Big Picture Coaches, Small Picture Coaches, Football Players and as an offstage actor Team Owners/Managers care about the result. The highest-level use case of the application is an MR Football Playbook. So, at the highest level, the final application will provide the functionality of a playbook in mixed reality.

Highest Level System Context Diagram



Going into things a bit lower the system is supported by an external system in the Cloud backend. The three highest-level functional areas are: Authoring Plays, Viewing With AR, and Simulating Plays. Authoring Plays refers to the overall ability of a coach to create, edit, and delete a play in the iOS application. Viewing with AR refers to functionality in HoloLens 2 application. On the HoloLens application, the players' positions and their routes are shown in AR to the user and meeting the first advanced computer science area: Mixed Reality. Finally, simulating plays refers to the movement of players along their routes in a simulation of the play providing a whole new visual aspect to football play design and studying, while also constituting our second advanced computer science area: Simulation and Visualization.

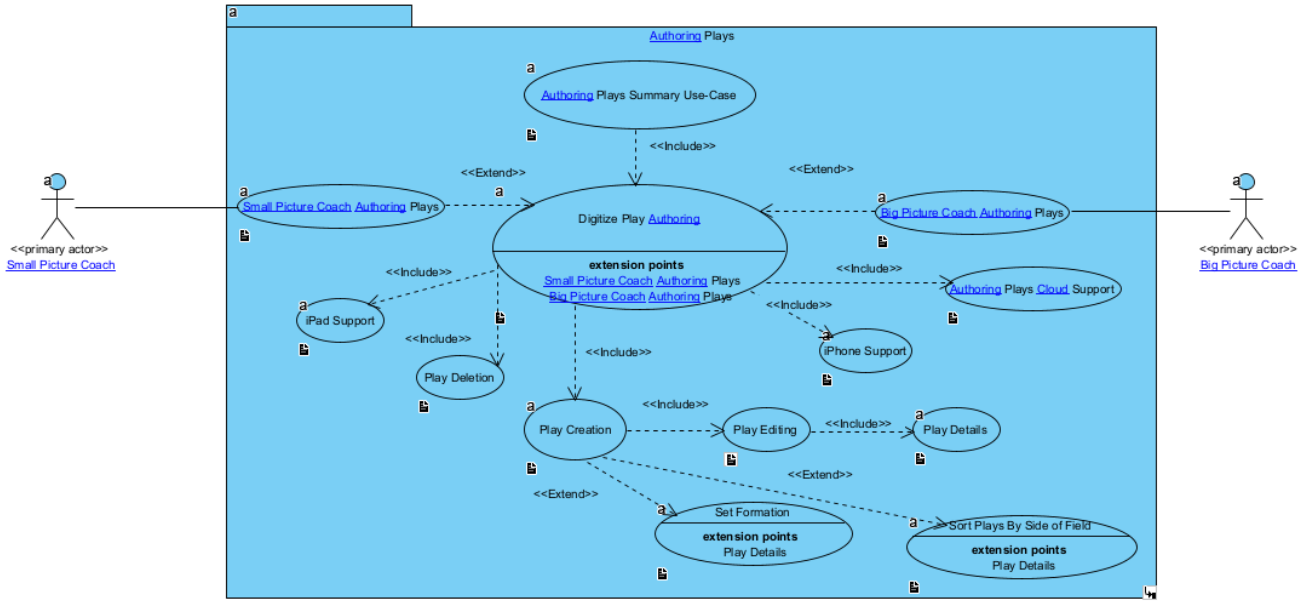
Use-Case Summary Diagram



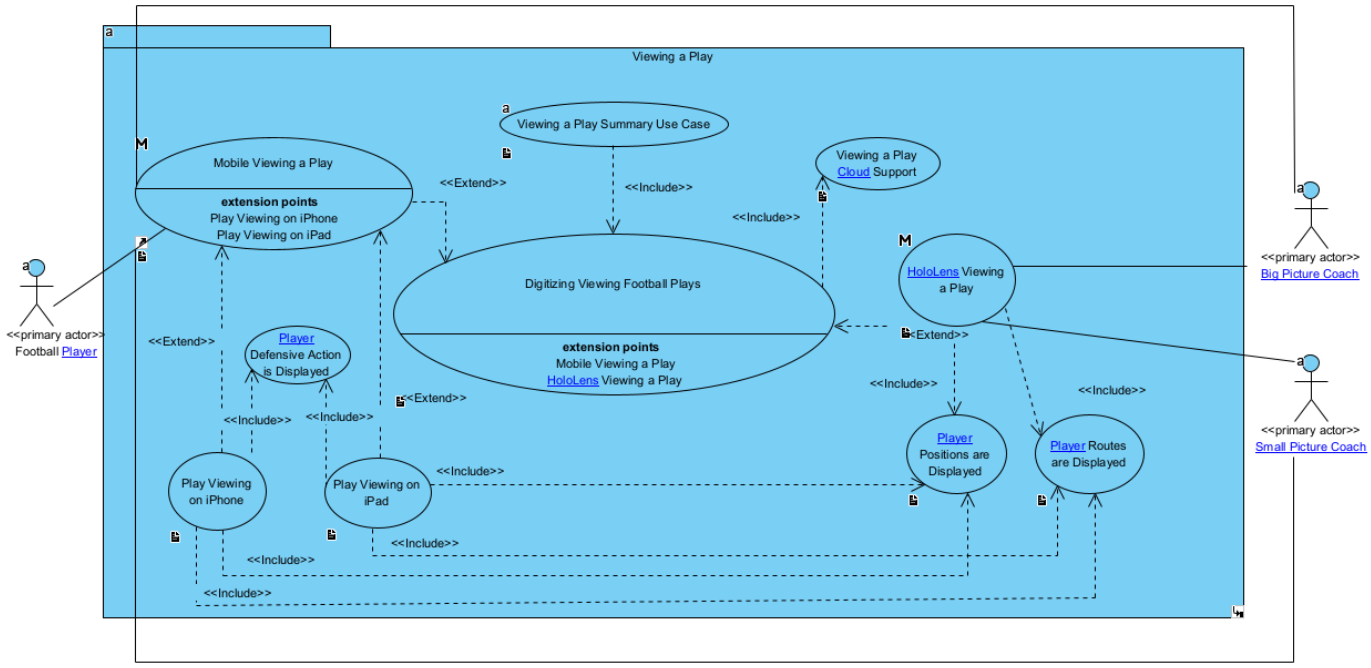
USE-CASES

To go further into the details of the use cases the diagrams below give a good picture of what each summary entails and what actors are involved in each area and use-case.

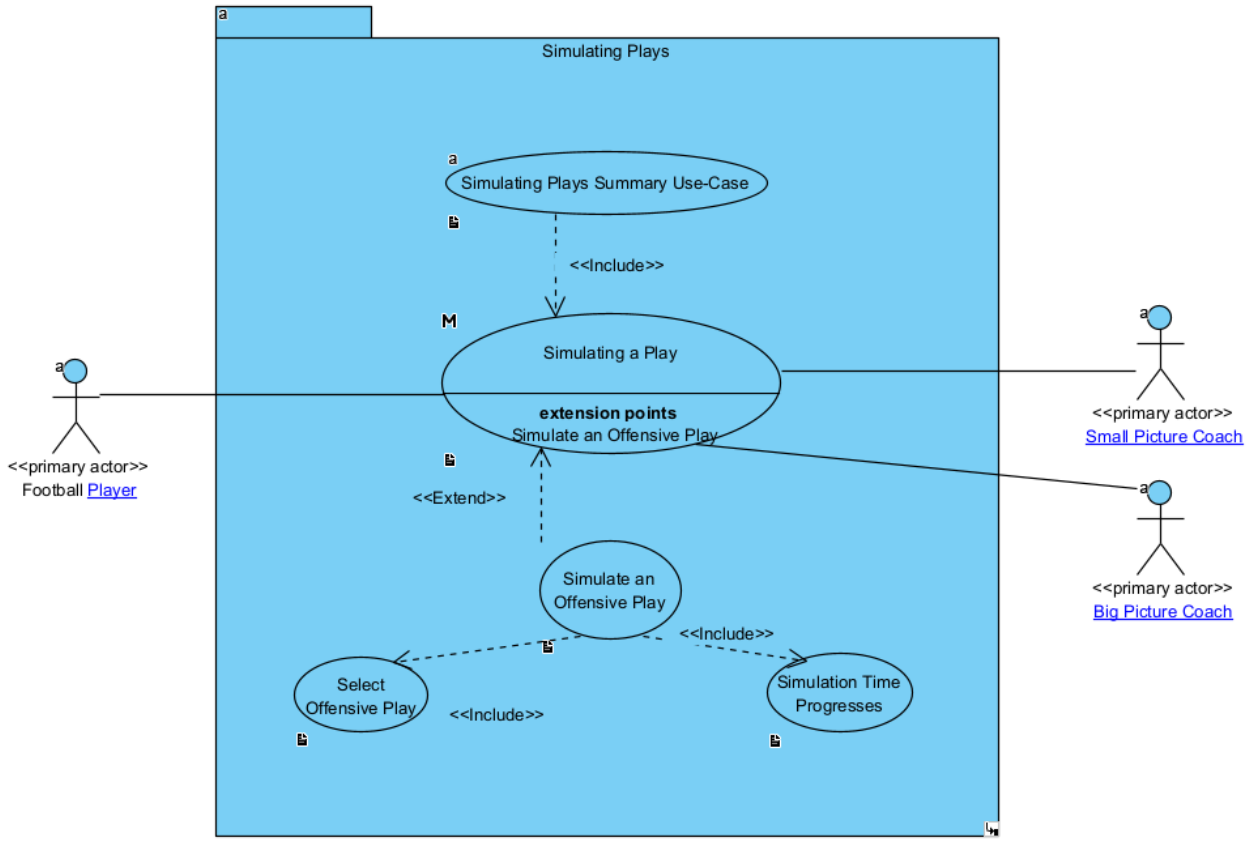
The Authoring Plays Functional Area



The Viewing with AR Functional Area



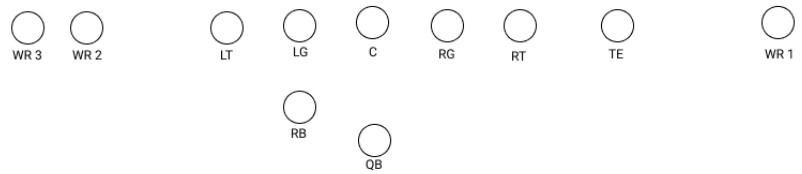
The Simulating Plays Functional Area

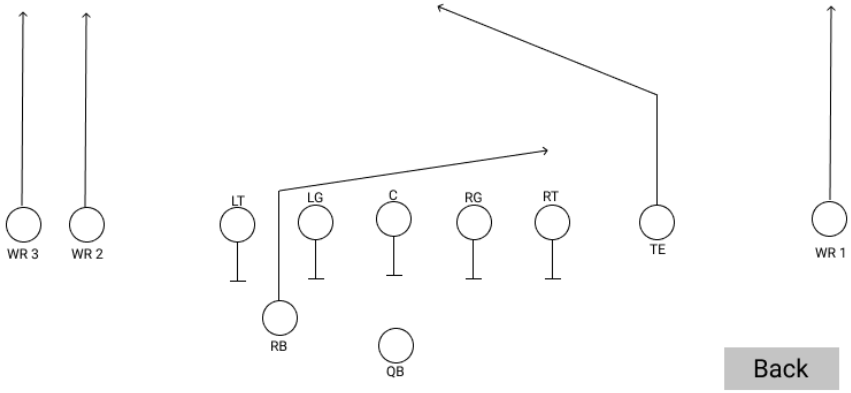


USER INTERFACE

Below are our UI Design Examples we created in Figma. The first design shows an example of the setup for initial play positions for the Four Verticals play. The next design shows the same play but with routes set. Finally, the last design shows our design for the HoloLens menu.

Offence - Example Positions





Offence - Example Play

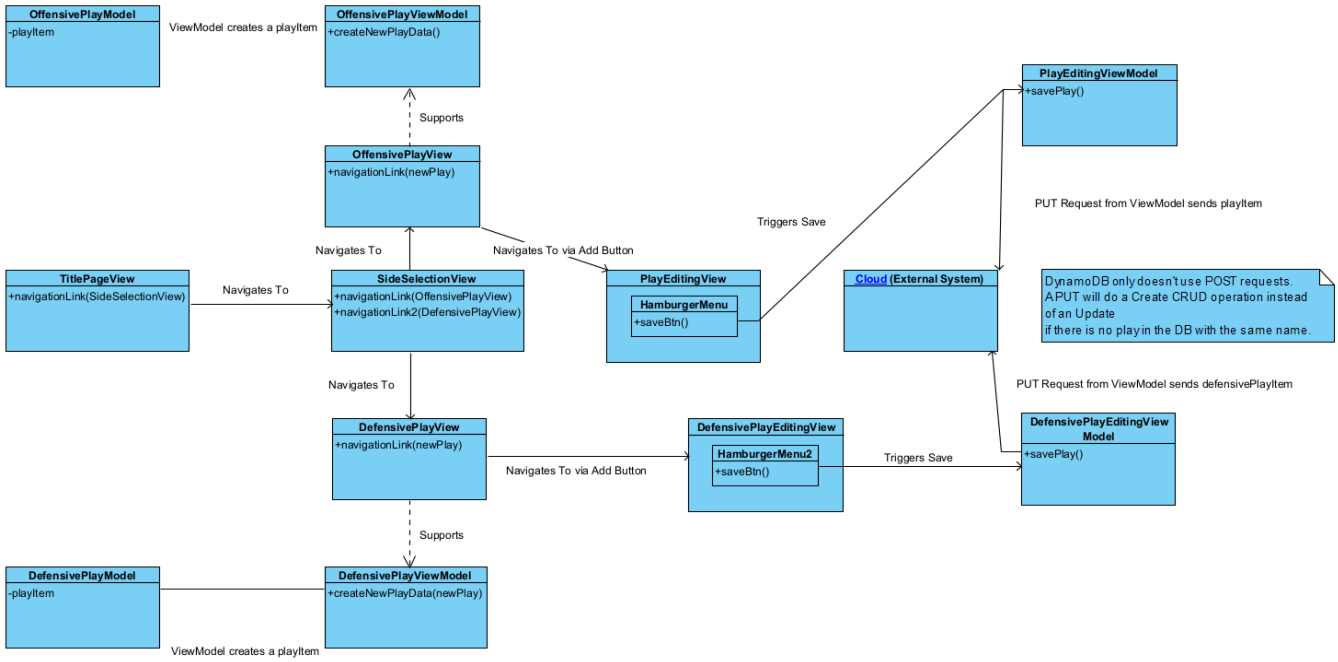
PROJECT ARCHITECTURE

This section contains the details of the Architecture of the project. This includes an overview of the interactions of the system for each of the main use cases, the overview of the entire system, the more specific logic diagrams of the HoloLens and iOS applications, and the major system components of the backend and the overall system in the deployment model.

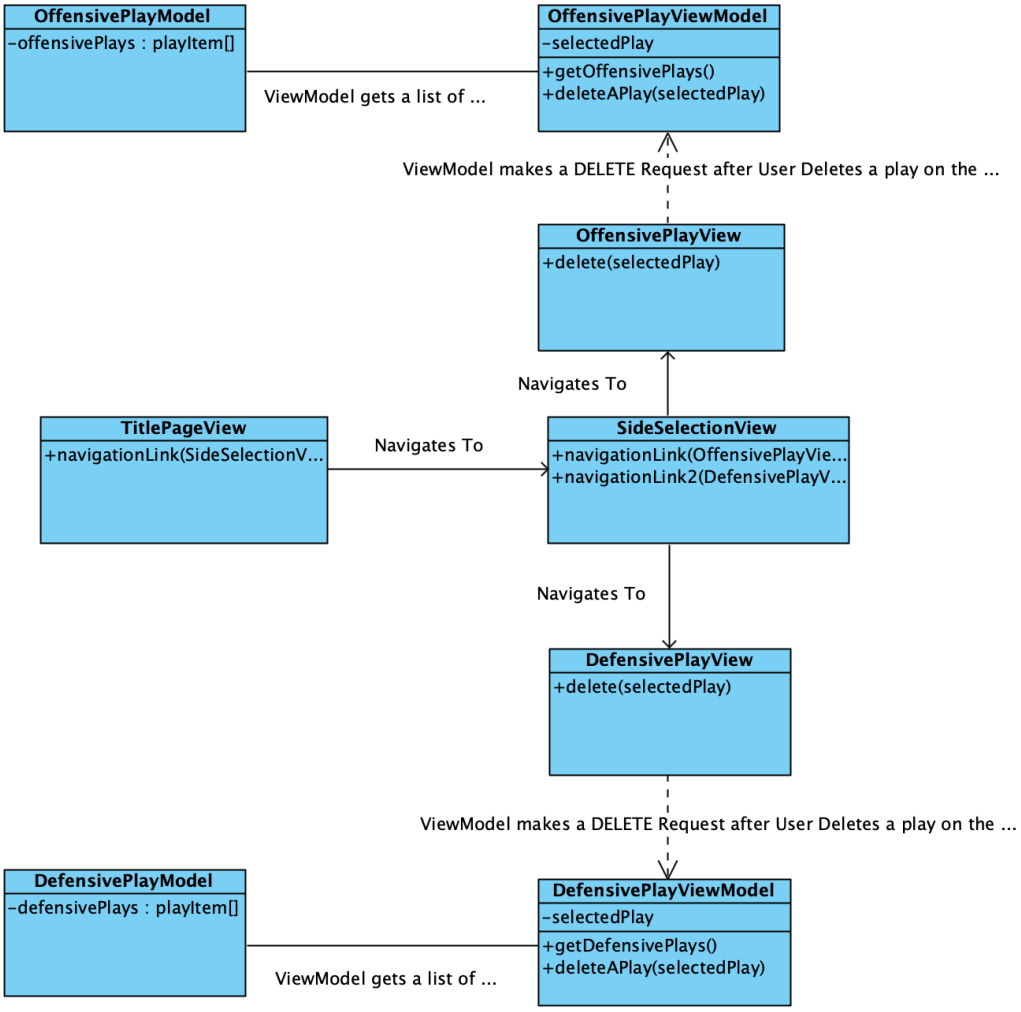
Visual Paradigm Link: https://online.visual-paradigm.com/w/wleigogf/diagrams/#diagram:workspace=wleigogf&proj=3&id=5

Authoring Plays Interaction Diagrams

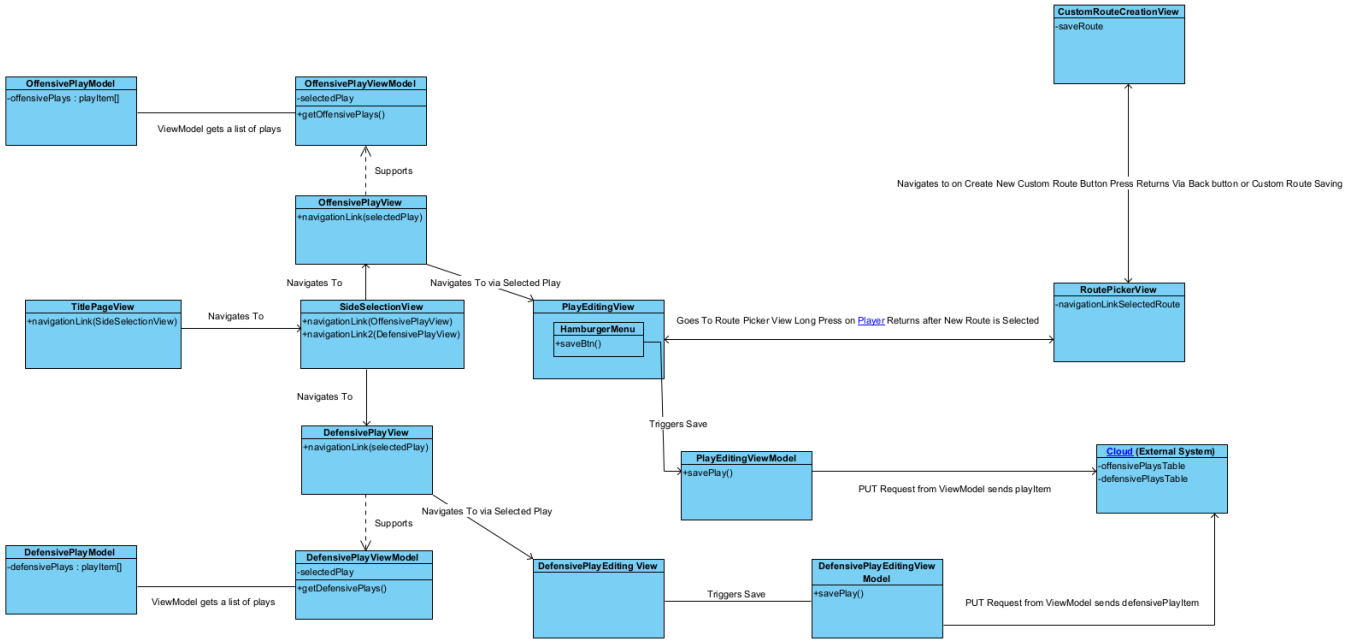
Play Creation



Play Deletion

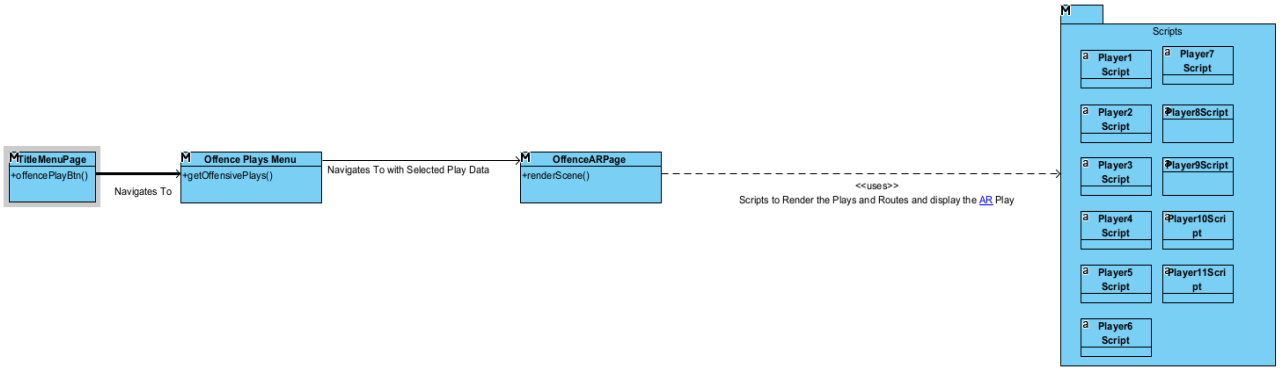


Play Editing

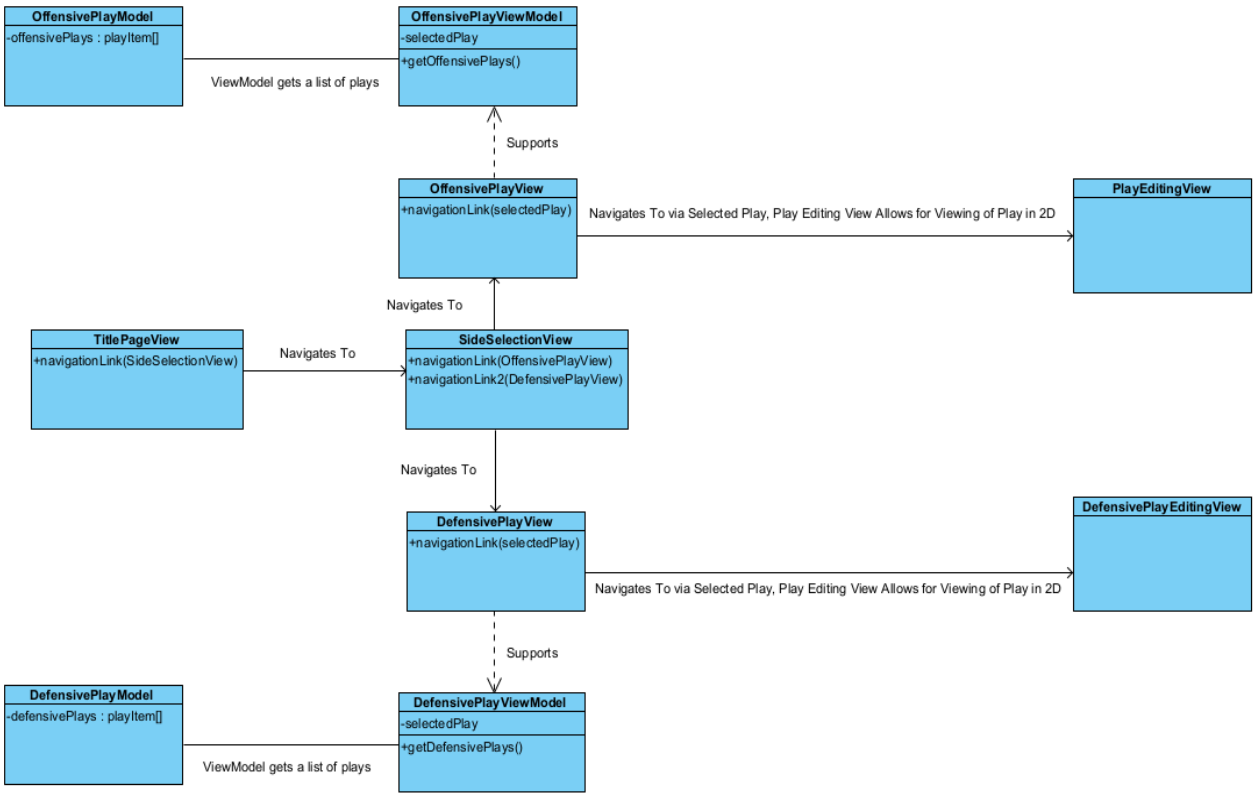


Viewing Plays Interaction Diagrams

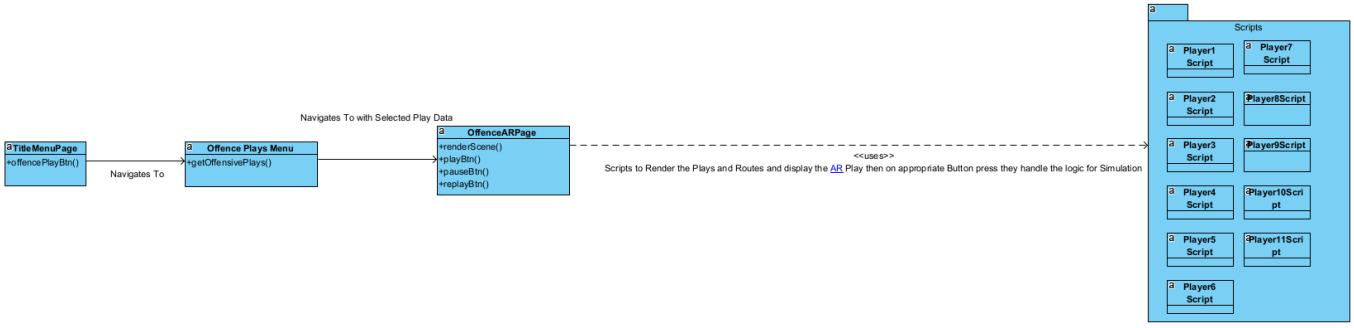
HoloLens Viewing



Mobile Viewing



Simulating Plays Interaction Diagrams

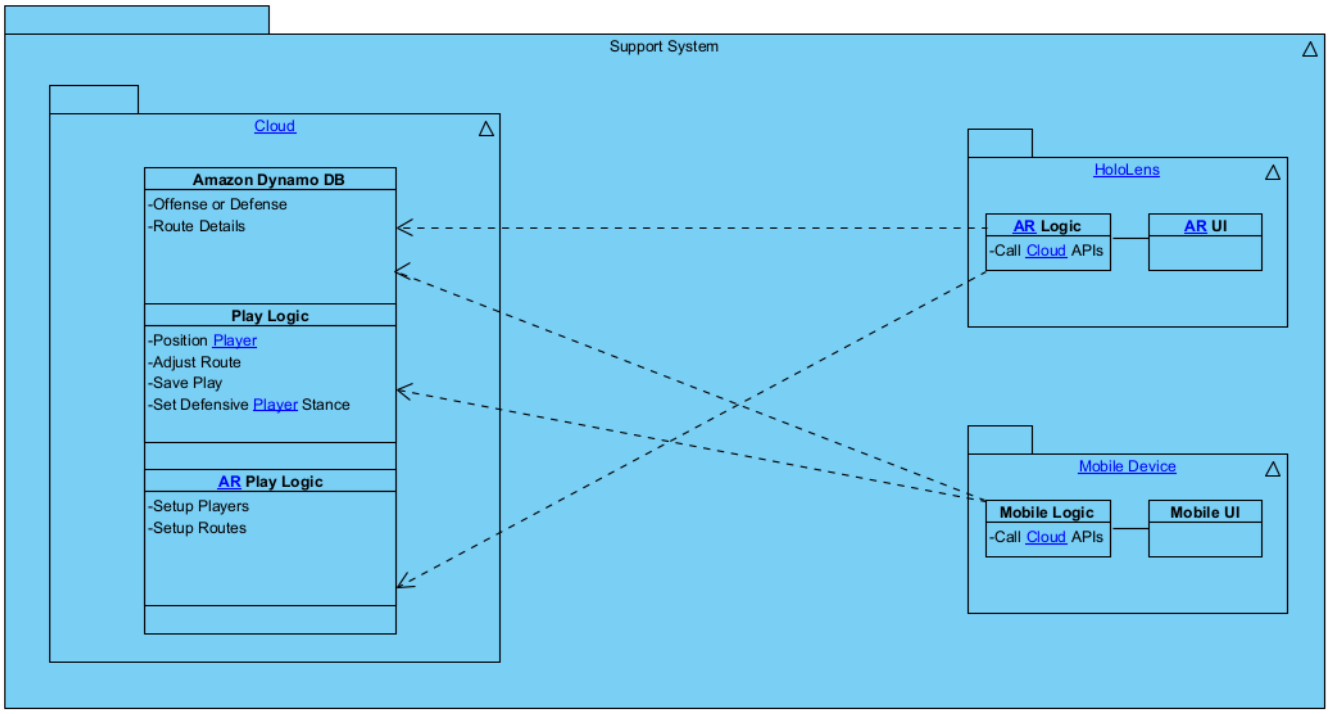


ARCHITECTURE OVERVIEW

The overall architecture of the project is Client-Server architecture. We chose to structure our project in this manner because conceptually the iOS application should be able to be run by all the coaches and the HoloLens application by

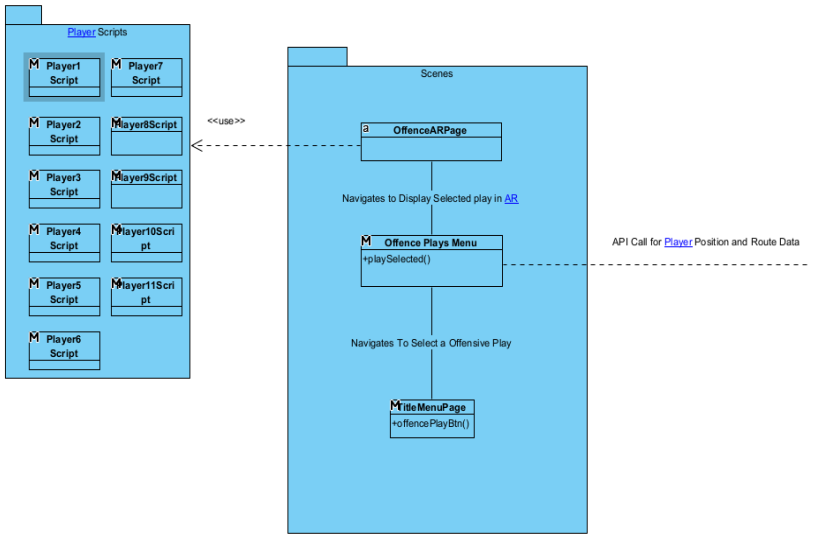
multiple players. With a client server architecture much of the resource usage falls on the server instead of the devices. This is something that we identified would be especially important as even in the HoloLens proof of concept application we (with not all the logic on the cloud yet) already takes about 2 minutes for a single deployment, an unacceptable amount of time.

Overall System Diagram

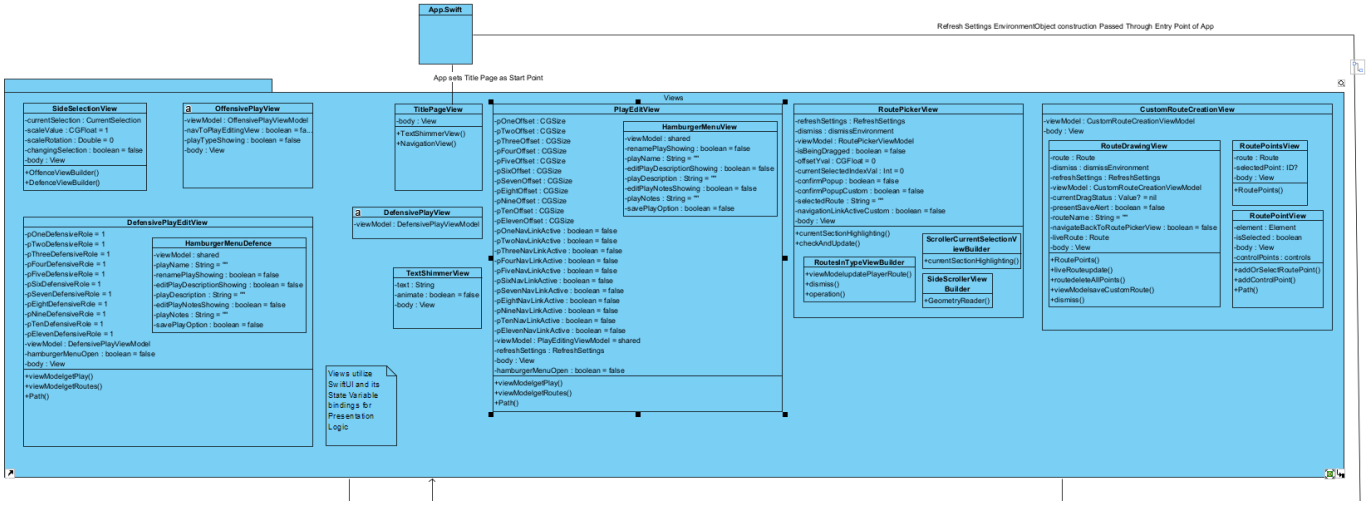


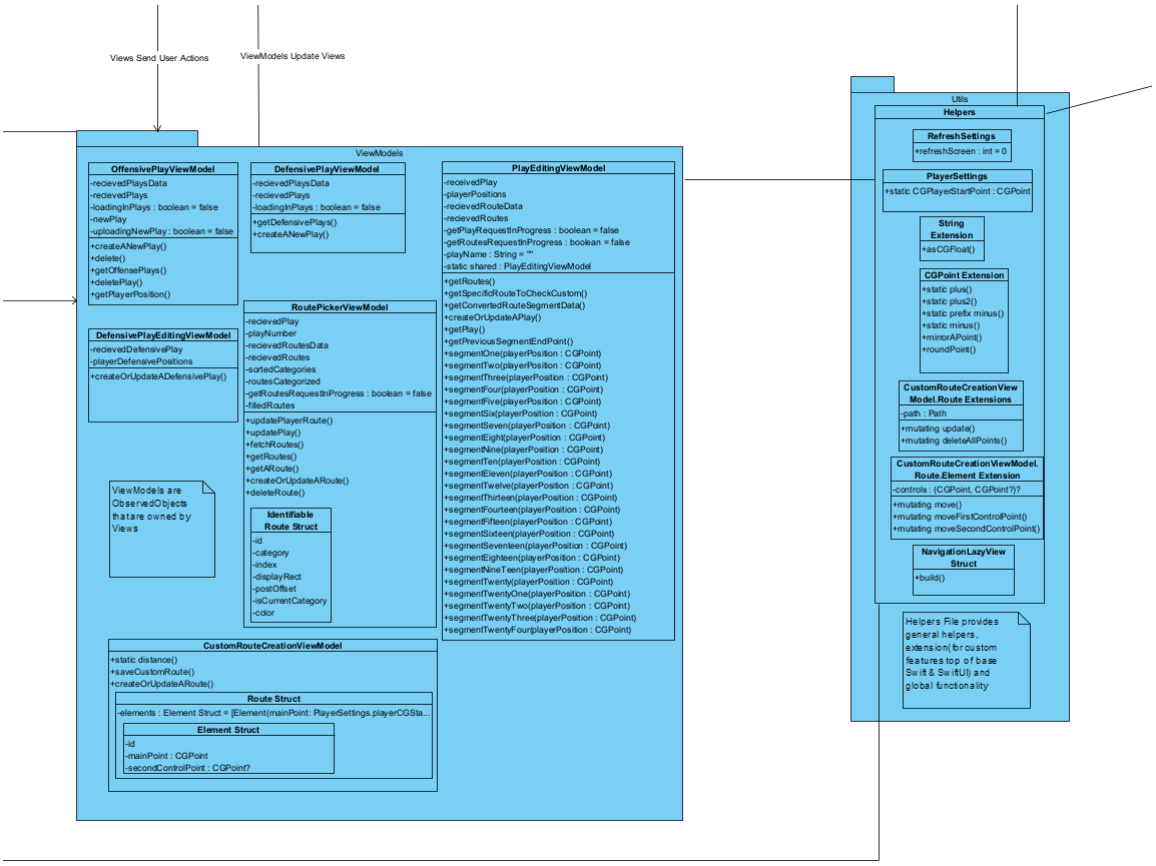
The concept of the overall system follows Client-Server Architecture principles. The cloud handles DB, Play positioning and simulation logic. The HoloLens and Mobile Device only need to handle their own UIs and make the API calls. In our proof of concept only some logic is on the cloud, but we expect to have this separation be much greater in the future.

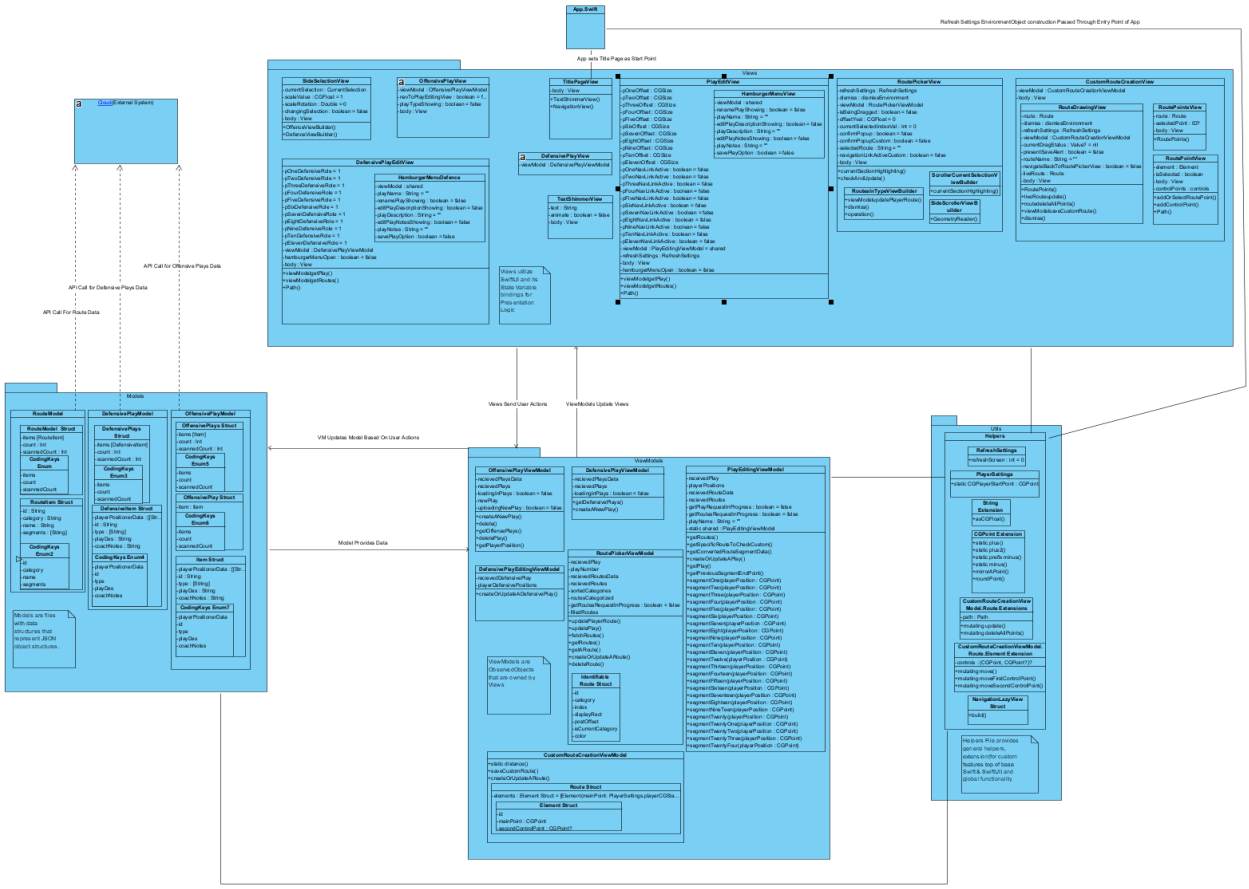
HoloLens Application Logic Diagram



Mobile Application Logic Diagram



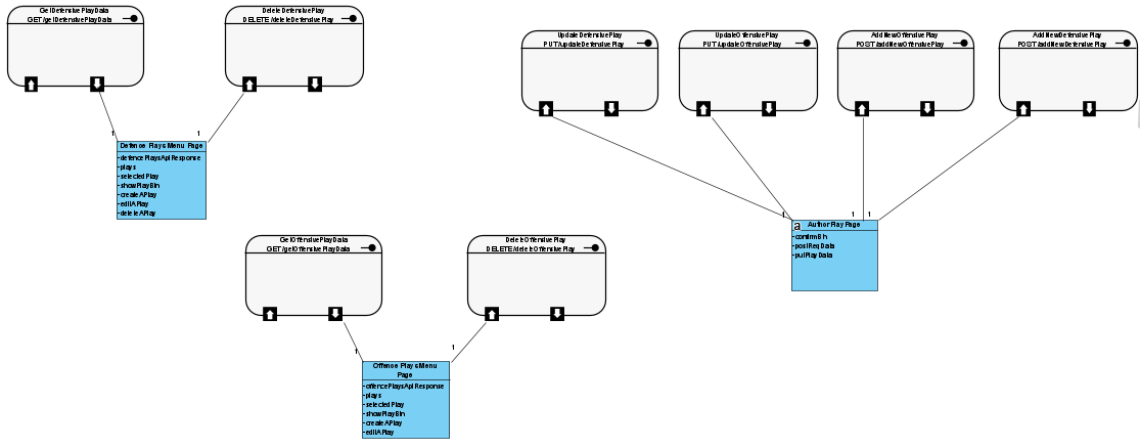

Views Send User Actions
ViewModels Update Views
ViewModels
OffensivePlayViewModel
-recievedPlaysData
-recievedPlays
-loadingInPlays : boolean = false
-newPlay
-uploadingNewPlay : boolean = false
+createANewPlay()
+delete()
+getOffensePlays()
+deletePlay()
+getPlayerPosition()
DefensivePlayViewModel
-recievedPlaysData
-recievedPlays
-loadingInPlays : boolean = false
+getDefensivePlays()
+createANewPlay()
PlayEditingViewModel
-receivedPlay
-playerPositions
-recievedRouteData
-recievedRoutes
-getPlayRequestInProgress : boolean = false
-getRoutesRequestInProgress : boolean = false
-playName : String = ""
-static shared : PlayEditingViewModel
+getRoutes()
+getSpecificRouteToCheckCustom()
+getConvertedRouteSegmentData()
+createOrUpdateAPlay()
+getPlay()
+getPreviousSegmentEndPoint()
+segmentOne(playerPosition : CGPoint)
+segmentTwo(playerPosition : CGPoint)
+segmentThree(playerPosition : CGPoint)
+segmentFour(playerPosition : CGPoint)
+segmentFive(playerPosition : CGPoint)
+segmentSix(playerPosition : CGPoint)
+segmentSeven(playerPosition : CGPoint)
+segmentEight(playerPosition : CGPoint)
+segmentNine(playerPosition : CGPoint)
+segmentTen(playerPosition : CGPoint)
+segmentEleven(playerPosition : CGPoint)
+segmentTwelve(playerPosition : CGPoint)
+segmentThirteen(playerPosition : CGPoint)
+segmentFourteen(playerPosition : CGPoint)
+segmentFifteen(playerPosition : CGPoint)
+segmentSixteen(playerPosition : CGPoint)
+segmentSeventeen(playerPosition : CGPoint)
+segmentEighteen(playerPosition : CGPoint)
+segmentNineTeen(playerPosition : CGPoint)
+segmentTwenty(playerPosition : CGPoint)
+segmentTwentyOne(playerPosition : CGPoint)
+segmentTwentyTwo(playerPosition : CGPoint)
+segmentTwentyThree(playerPosition : CGPoint)
+segmentTwentyFour(playerPosition : CGPoint)
DefensivePlayEditingViewModel
-recievedDefensivePlay
-playerDefensivePositions
+createOrUpdateADefensivePlay()
RoutePickerViewModel
-recievedPlay
-playNumber
-recievedRoutesData
-recievedRoutes
-sortedCategories
-routesCategorized
-getRoutesRequestInProgress : boolean = false
-filledRoutes
+updatePlayerRoute()
+updatePlay()
+fetchRoutes()
+getRoutes()
+getARoute()
+createOrUpdateARoute()
+deleteRoute()
Identifiable Route Struct
-id
-category
-index
-displayRect
-postOffset
-isCurrentCategory
-color
ViewModels are ObservedObjects that are owned by Views
CustomRouteCreationViewModel
+static distance()
+saveCustomRoute()
+createOrUpdateARoute()
Route Struct
-elements : Element Struct = [Element(mainPoint: PlayerSettings.playerCGSta...
Element Struct
-id
-mainPoint : CGPoint
-secondControlPoint : CGPoint?
Utils
Helpers
RefreshSettings
+refreshScreen : int = 0
PlayerSettings
+static CGPlayerStartPoint : CGPoint
String Extension
+asCGFloat()
CGPoint Extension
+static plus()
+static plus2()
+static prefix minus()
+static minus()
+minorAPoint()
+roundPoint()
CustomRouteCreationView Model.Route Extensions
-path : Path
+mutating update()
+mutating deleteAllPoints()
CustomRouteCreationViewModel. Route.Element Extension
-controls : (CGPoint, CGPoint?)?
+mutating move()
+mutating moveFirstControlPoint()
+mutating moveSecondControlPoint()
NavigationLazyView Struct
+build()
Helpers File provides general helpers, extension(for custom features top of base Swift & SwiftUI) and global functionality



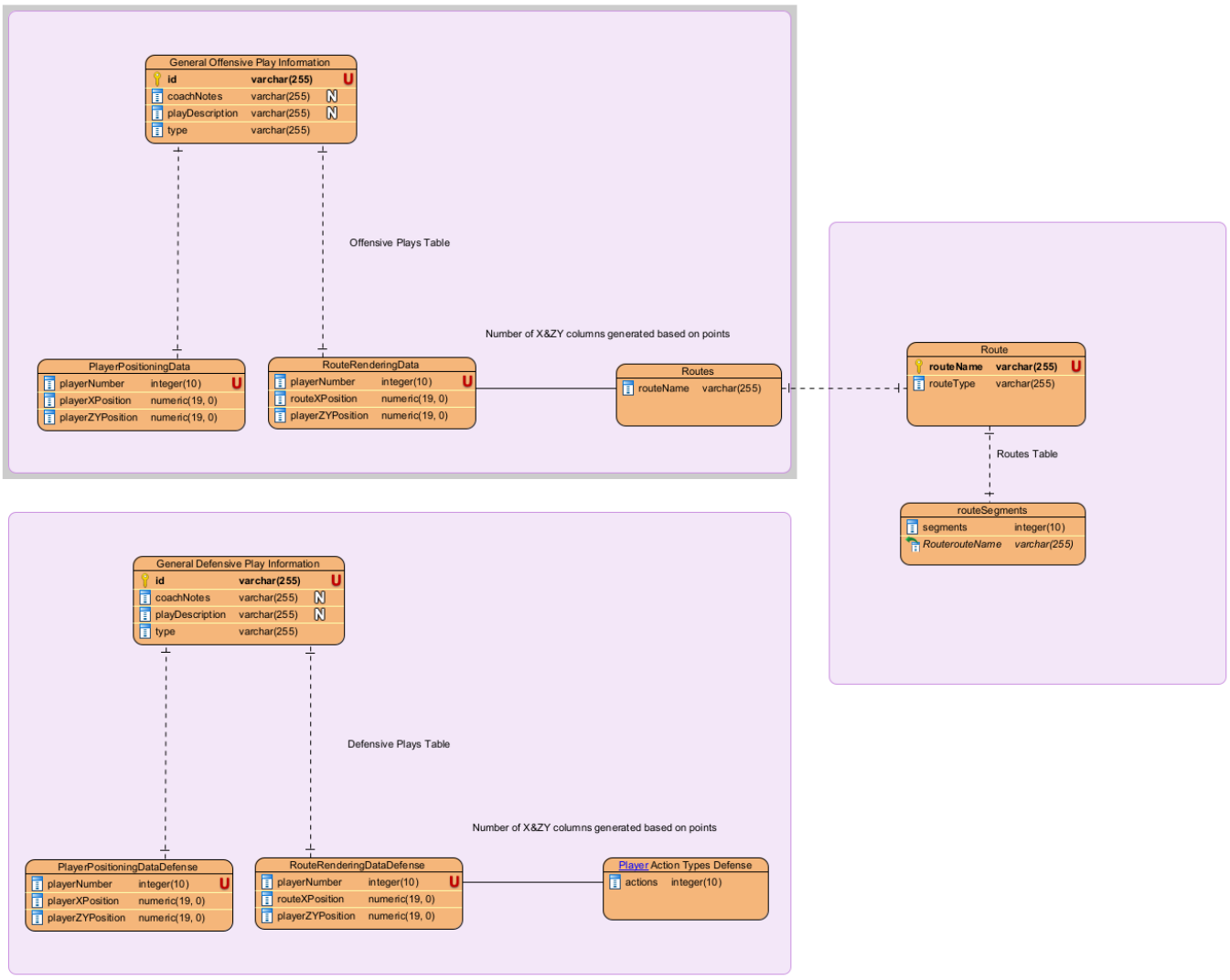
SYSTEM COMPONENTS

The main components of the system are most easily viewed in the deployment model below. However, some major components that may not be as clear in the model but are shown below are: The RESTful APIs used to manage Play data and the DB entity relationship diagram. The APIs facilitate communication between the HoloLens and the cloud and Mobile device and the cloud following principles of Client-Server architecture. Meanwhile, all the play data required to render player positions and routes are stored in the database. This database is what the APIs through the AWS Lambda functions send data to and return data from.

RESTful APIs Overview Diagram



Dynamo DB Diagram



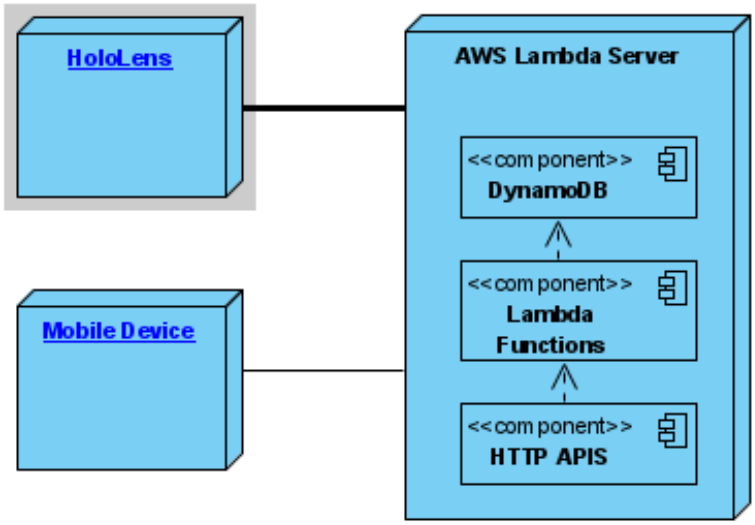
DEPLOYMENT MODEL

Mobile Device: iPhone the application is a native iOS application created utilizing SwiftUI.

Cloud Platform: AWS Cloud services are being utilized in a three-part manner. First, the endpoints are accessible via the AWS Cloud API Gateway services. Then these API Gateway services have an integration with AWS Lambda Function that contains the code for the functionality of the CRUD operations. Finally, the Lambda Functions are integrated with AWS DynamoDB, a fully managed NoSQL database with a key-value structure that contains all player positioning data and route data for a play.

HoloLens: The HoloLens application is created in C# .NET with Unity Engine integration. It utilizes C# scripts along with the .NET WebClient and Newtonsoft to handle all API requests and responses as well as JSON deserialization and feeding of the API data to the Unity shapes.

Deployment Model Diagram



PROJECT PLAN

https://footballcapstone.atlassian.net/jira/software/projects/FVPPP/boards/3/backlog

Roles Overview

Name	Role & Responsibility
Max Komor	Project Owner: Also, software architect, and Small Picture Coach Stakeholder
Mike Komor	SCRUM Master: Also, QA Lead and Big picture coach stakeholder
Muhammed Mooraja	Risk Analyst: Also, requirements/business analyst and Football player stakeholder

ITERATION PLAN

The Iterations are broken down into logical step by step progression. Beginning with some basic UI, followed by architecture, and moving on to business logic.

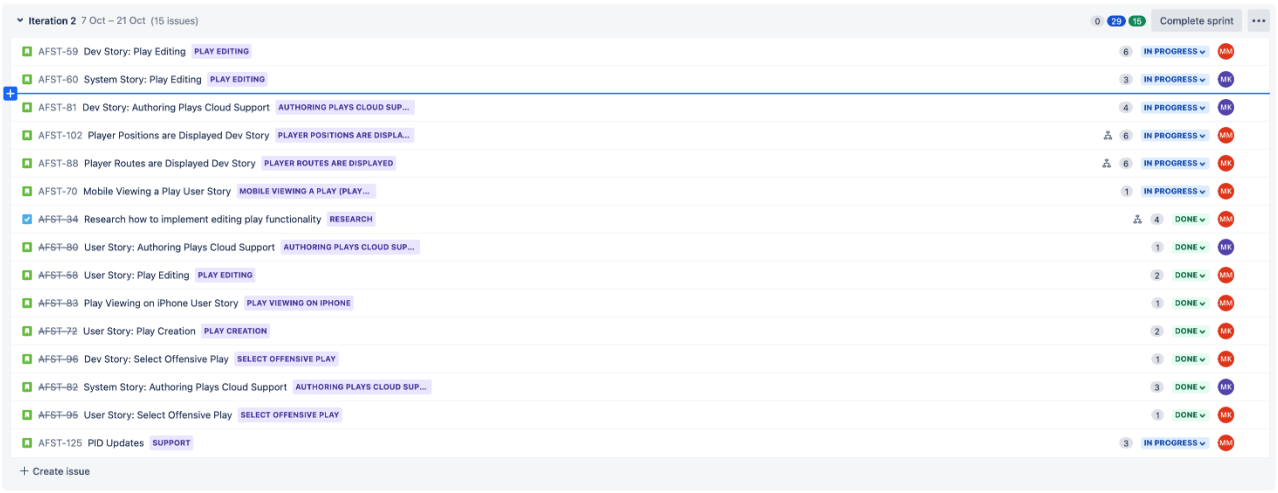
Overall, this was our thought process for our iteration plan:

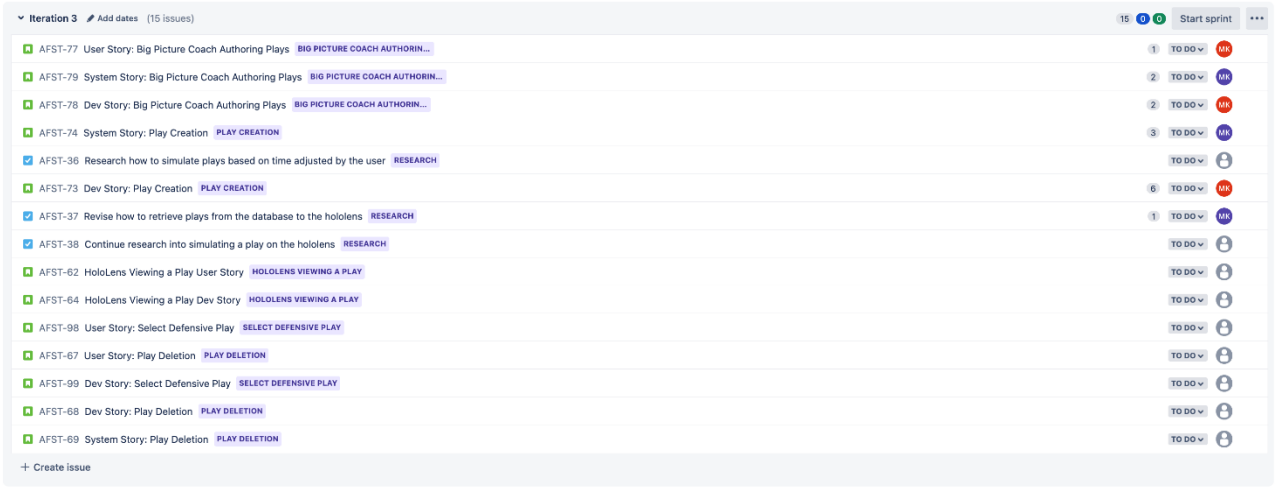
Iteration Plan

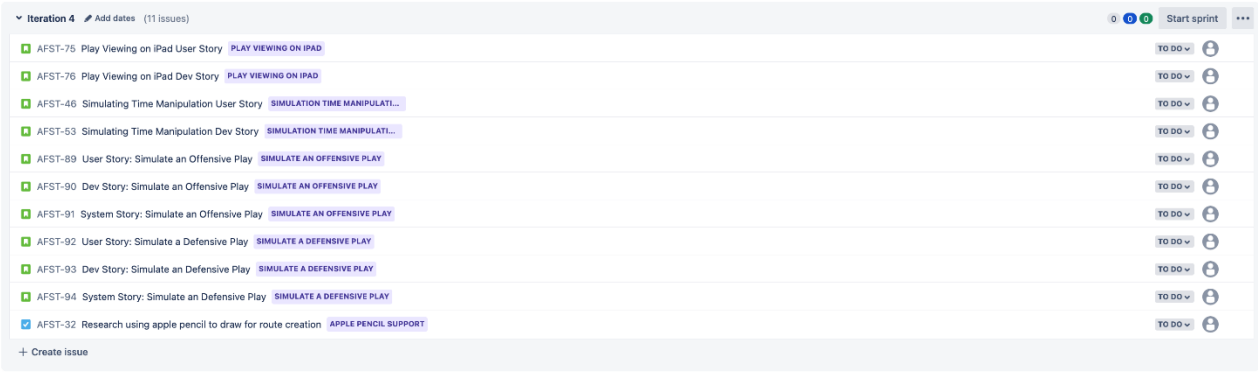
Report: Iteration 1

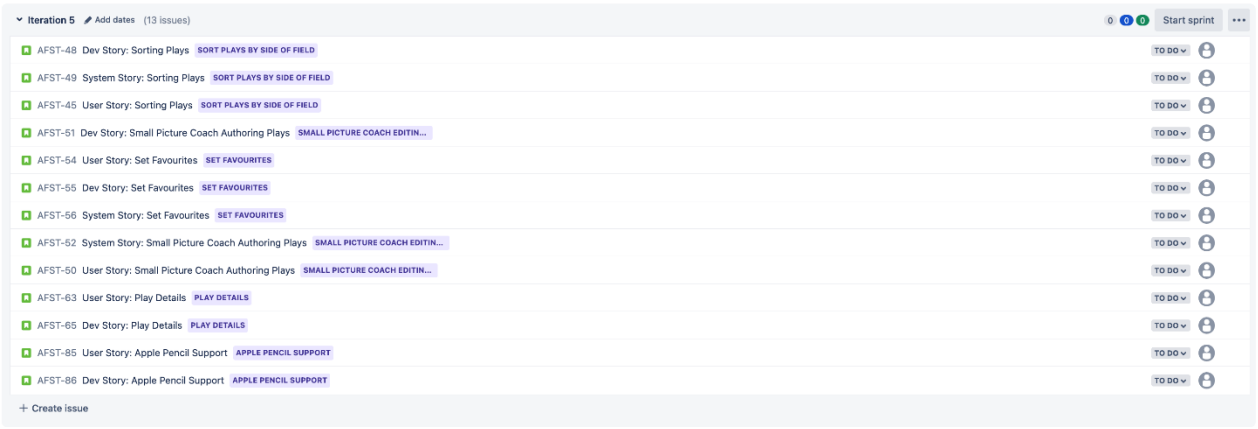
Scope changes log

Date	Key	Summary	Issue type	Epic
2022-09-29	AFST-61	Viewing A Play Cloud Support System Story	Story	
2022-09-29	AFST-33	Revise how to retrieve/save/delete plays to/from the database from an iPhone or i...	Task	RESEARCH
2022-09-29	AFST-87	Player Routes are Displayed User Story	Story	PLAYER ROUTES ...
2022-09-29	AFST-101	Player Positions are Displayed User Story	Story	PLAYER POSITIO...
2022-09-29	AFST-88	Player Routes are Displayed Dev Story	Story	PLAYER ROUTES ...
2022-09-29	AFST-102	Player Positions are Displayed Dev Story	Story	PLAYER POSITIO...
2022-09-29	AFST-70	Mobile Viewing a Play User Story	Story	MOBILE VIEWING ...
2022-09-29	AFST-83	Play Viewing on iPhone User Story	Story	PLAY VIEWING O...
2022-09-29	AFST-84	Play Viewing on iPhone Dev Story	Story	PLAY VIEWING O...
2022-09-29	AFST-70	Mobile Viewing a Play User Story	Story	MOBILE VIEWING ...
2022-09-29	AFST-83	Play Viewing on iPhone User Story	Story	PLAY VIEWING O...
2022-09-29	AFST-84	Play Viewing on iPhone Dev Story	Story	PLAY VIEWING O...
2022-09-29	AFST-71	Mobile Viewing a Play Dev Story	Story	MOBILE VIEWING ...
2022-10-12	AFST-83	Play Viewing on iPhone User Story	Story	PLAY VIEWING O...
2022-10-12	AFST-70	Mobile Viewing a Play User Story	Story	MOBILE VIEWING ...
2022-10-12	AFST-88	Player Routes are Displayed Dev Story	Story	PLAYER ROUTES ...
2022-10-12	AFST-102	Player Positions are Displayed Dev Story	Story	PLAYER POSITIO...


Iteration 2 7 Oct – 21 Oct (15 issues)
Complete sprint
AFST-59 Dev Story: Play Editing PLAY EDITING IN PROGRESS
AFST-60 System Story: Play Editing PLAY EDITING IN PROGRESS
AFST-81 Dev Story: Authoring Plays Cloud Support AUTHORING PLAYS CLOUD SUP... IN PROGRESS
AFST-102 Player Positions are Displayed Dev Story PLAYER POSITIONS ARE DISPLA... IN PROGRESS
AFST-88 Player Routes are Displayed Dev Story PLAYER ROUTES ARE DISPLAYED IN PROGRESS
AFST-70 Mobile Viewing a Play User Story MOBILE VIEWING A PLAY (PLAY... IN PROGRESS
AFST-34 Research how to implement editing play functionality RESEARCH DONE
AFST-80 User Story: Authoring Plays Cloud Support AUTHORING PLAYS CLOUD SUP... DONE
AFST-58 User Story: Play Editing PLAY EDITING DONE
AFST-83 Play Viewing on iPhone User Story PLAY VIEWING ON IPHONE DONE
AFST-72 User Story: Play Creation PLAY CREATION DONE
AFST-96 Dev Story: Select Offensive Play SELECT OFFENSIVE PLAY DONE
AFST-82 System Story: Authoring Plays Cloud Support AUTHORING PLAYS CLOUD SUP... DONE
AFST-95 User Story: Select Offensive Play SELECT OFFENSIVE PLAY DONE
AFST-125 PID Updates SUPPORT IN PROGRESS
Create issue

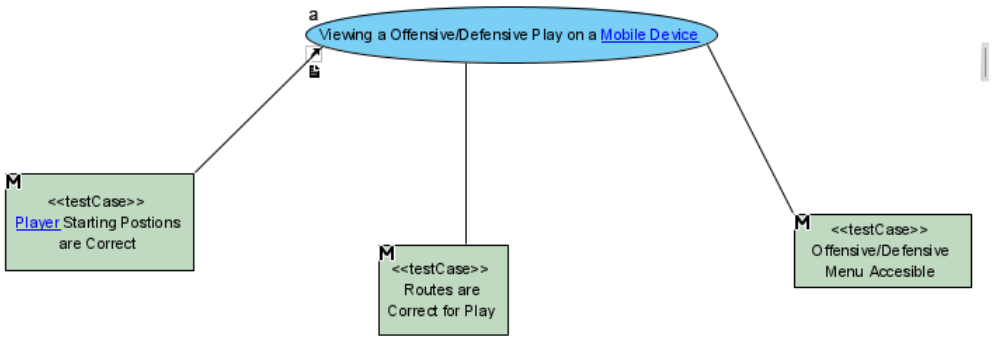

Iteration 3 Add dates (15 issues)
Start sprint
AFST-77 User Story: Big Picture Coach Authoring Plays BIG PICTURE COACH AUTHORIN... TO DO
AFST-79 System Story: Big Picture Coach Authoring Plays BIG PICTURE COACH AUTHORIN... TO DO
AFST-78 Dev Story: Big Picture Coach Authoring Plays BIG PICTURE COACH AUTHORIN... TO DO
AFST-74 System Story: Play Creation PLAY CREATION TO DO
AFST-36 Research how to simulate plays based on time adjusted by the user RESEARCH TO DO
AFST-73 Dev Story: Play Creation PLAY CREATION TO DO
AFST-37 Revise how to retrieve plays from the database to the hololens RESEARCH TO DO
AFST-38 Continue research into simulating a play on the hololens RESEARCH TO DO
AFST-62 HoloLens Viewing a Play User Story HOLOLENS VIEWING A PLAY TO DO
AFST-64 HoloLens Viewing a Play Dev Story HOLOLENS VIEWING A PLAY TO DO
AFST-98 User Story: Select Defensive Play SELECT DEFENSIVE PLAY TO DO
AFST-67 User Story: Play Deletion PLAY DELETION TO DO
AFST-99 Dev Story: Select Defensive Play SELECT DEFENSIVE PLAY TO DO
AFST-68 Dev Story: Play Deletion PLAY DELETION TO DO
AFST-69 System Story: Play Deletion PLAY DELETION TO DO
Create issue


Iteration 4 Add dates (11 issues)
Start sprint
AFST-75 Play Viewing on iPad User Story PLAY VIEWING ON IPAD TO DO
AFST-76 Play Viewing on iPad Dev Story PLAY VIEWING ON IPAD TO DO
AFST-46 Simulating Time Manipulation User Story SIMULATION TIME MANIPULATI... TO DO
AFST-53 Simulating Time Manipulation Dev Story SIMULATION TIME MANIPULATI... TO DO
AFST-89 User Story: Simulate an Offensive Play SIMULATE AN OFFENSIVE PLAY TO DO
AFST-90 Dev Story: Simulate an Offensive Play SIMULATE AN OFFENSIVE PLAY TO DO
AFST-91 System Story: Simulate an Offensive Play SIMULATE AN OFFENSIVE PLAY TO DO
AFST-92 User Story: Simulate a Defensive Play SIMULATE A DEFENSIVE PLAY TO DO
AFST-93 Dev Story: Simulate an Defensive Play SIMULATE A DEFENSIVE PLAY TO DO
AFST-94 System Story: Simulate an Defensive Play SIMULATE A DEFENSIVE PLAY TO DO
AFST-32 Research using apple pencil to draw for route creation APPLE PENCIL SUPPORT TO DO
Create issue



VALIDATION AND TESTING

Example Use Case Test Plan for viewing in AR on Mobile:



TESTING STRATEGY

The overall testing strategy is broken down based around the major functional areas and use cases. Overall, throughout the development process we are using built-in environment debuggers to catch obvious errors such as null pointers. Overall, test cases have been created as part of the testing strategy based around use cases that follow procedural steps around expected outcomes. The expectation is that per our iteration plan, we will focus extensively

on implementing the testing plan during our last iteration, however, we will be doing some test cases on earlier features that are a basis for others before then.

VALIDATION RESULTS

Currently, with our testing during development we have encountered multiple ways as discussed in our future work section of improving the quality of the work. However, overall, we have made considerable progress in future proofing our proof of concept so that as we add more features, minimal changes will need to occur for the viewing and simulation that we have implemented thus far.

CONCLUSION

Our solution of creating a HoloLens2 AR application that allows coaches to show plays to their players and simulate them in real time is bringing the next generation of play creation and education to life. Adding the 3rd dimension to these traditional methods while only increasing the accessibility of these tools through the HoloLens based application allows players to really take their game to the next level.

PROJECT SUITABILITY

After a very steep learning curve into AR development, we are more confident than ever that our idea is perfectly feasible from a developmental perspective. Due to the COVID19 pandemic after repeated attempts to find a suitable domain expert, Mike has had to take on this role. He has a vast wealth of knowledge on American football as he has watched it since early childhood and played football throughout high school. Even after injury, he assisted the coaches with game preparation and player involvement when he was unable to play. Due to this he was able to have experience on both sides of this application's intended audience. As a player he believes strongly in the visualization and simulation of plays as this is something that he felt was lacking with the traditional methods.

DOMAIN EXPERT EVALUATION

Professor David Horachek provided a great deal of insight for us to guide us in the process of learning AR development. He gave us the information to understand that we needed to pivot the original idea due to hardware limitations and gave us some recommendations as to where to look for learning about AR development.

USER TESTIMONIALS

The product has been tested by our peers and members of the team to generally positive user testimonials.

FUTURE WORK

In terms of future work to be done for the mobile application, the work would be focused around improving the robustness of the application, expanding upon the user and group access authentication, as well as additional UI improvements.

On the HoloLens side of the application, we have discussed potentially adding authoring functionality on the HoloLens as well and with that added, some authentication will also be needed to separate level of access for coaches and players.

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