Ball Spinner Milestone 1

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Presentation Overview

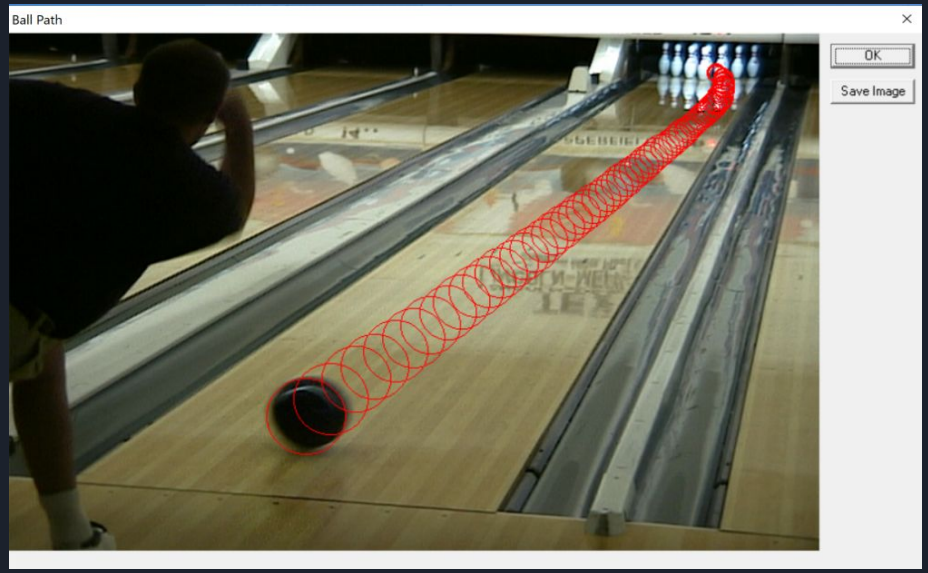
- Background
  - RevMetrix, SmartDot, Ciclopes, Ball Spinner
- Project Overview
- Tools & technologies
- Current Design
  - UMLs and schemas
- Current Implementations
- Demos
- Future implementations
- Conclusion

RevMetrix Background

- Brainchild of Professor Hake and Dr. Babcock
- Combination of Ciclopes and SmartDot Module
- Both compliment each other with supplemental data
- Application:
  - Bowling Oil Companies
  - Coaching
  - Semi-Professional leagues

What is Ciclopes

- Dr. Babcock's contribution
- External bowling analysis



Ciclopes - Bowler1

File Edit View Tools Camera Window Help

Bowler1

60'
45'
30'
15'

Personal Information

Name [ ]
Date [9/18/2023]
Center [ ]
Notes [ ]

Statistical Information

	Mean	Min	Max	Range
Initial Speed (mph)	16.78	16.62	17.03	0.42
Average Speed (mph)	15.66	15.37	15.90	0.54
Launch Angle (deg)	-2.15	-2.33	-2.03	0.30
Entry Angle (deg)	7.13	6.66	7.89	1.23
Loft Distance (ft)	2.44	1.03	4.43	3.40
Laydown Board	21.49	20.52	22.18	1.66
Arrow Board	15.71	15.05	16.19	1.14
Pindeck Board	17.26	16.88	17.56	0.69
Breakpoint Distance (ft)	42.34	41.91	42.82	0.91
Breakpoint Board	4.85	4.10	5.37	1.27
Shots	ALL			

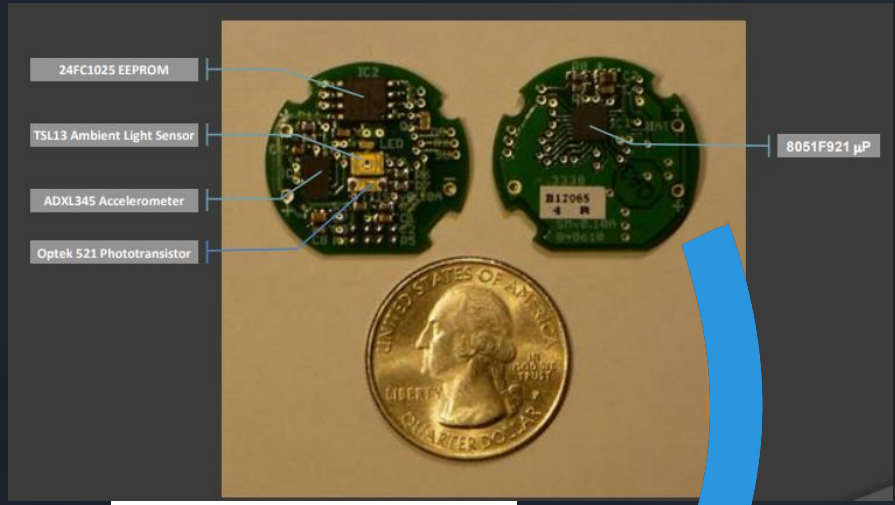
Shot Information

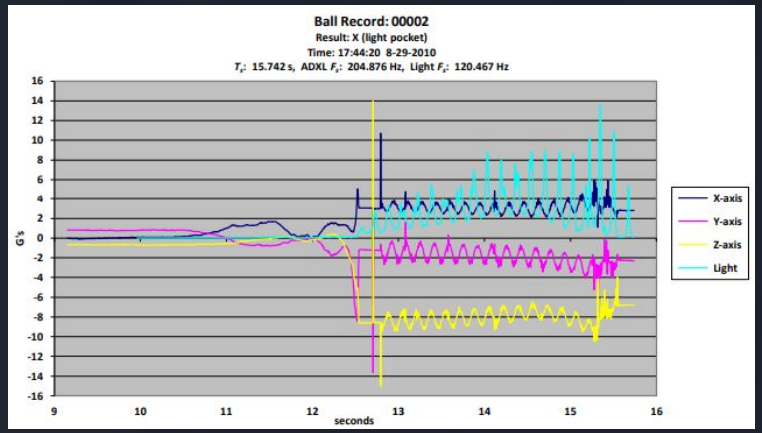
	Shot 1	Shot 2	Shot 3
Initial Speed (mph)	17.03	16.62	16.68
Average Speed (mph)	15.90	15.71	15.37
Launch Angle (deg)	-2.03	-2.09	-2.33
Entry Angle (deg)	6.66	6.83	7.89
Loft Distance (ft)	1.85	4.43	1.03
Laydown Board	21.79	20.52	22.18
Arrow Board	16.19	15.87	15.05
Pindeck Board	16.88	17.34	17.56
Breakpoint Distance (ft)	42.82	42.29	41.91
Breakpoint Board	5.37	5.10	4.10
Result	X	X	X

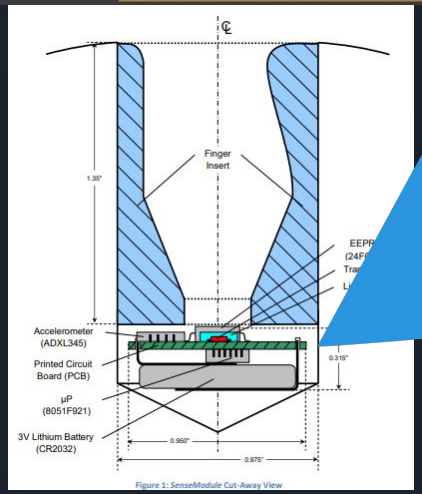
Ready

What is SmartDot

- Professor Hake's Brain-Child
- Light Sensor + Accelerometer

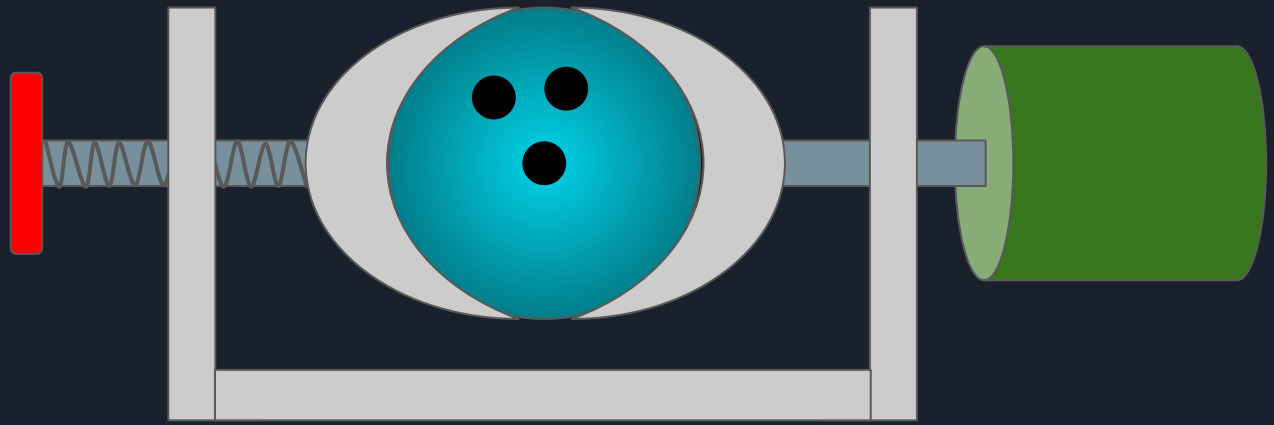






What is the Ball Spinner?

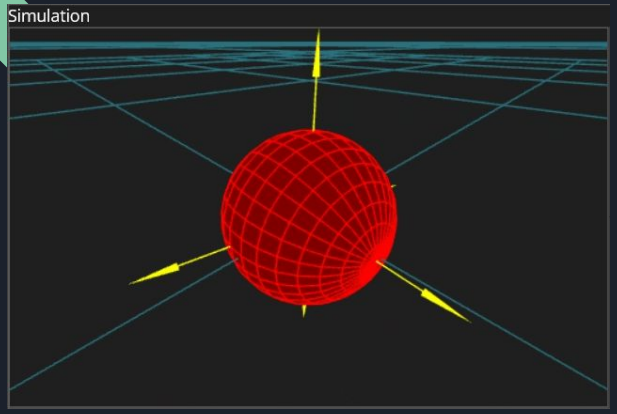
- Device that can emulate a throw down a lane
- Controls movement across 3 orthogonal axes of spin
- External sensors generate data

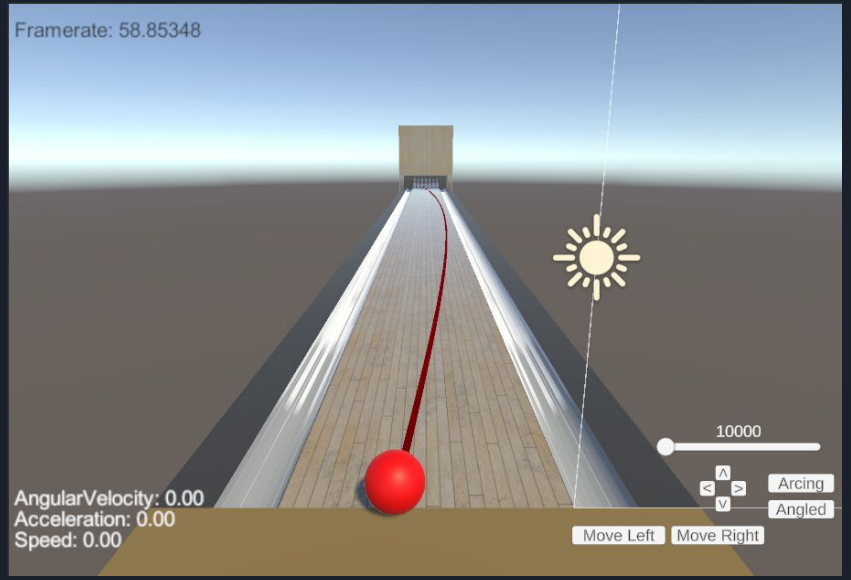


Questions?

Project Overview

Simulation





- Shows ball rotation
- Visualizes data through graphs
- Choice between real data from smartdot, and a simulated version of a possible shot
- Unity game with movable shot origin and a possible curve

BSA Backend

- Client-side API methods to interact with API server
- Processing of incoming/outgoing data
- Facilitates data transaction with local database

Cloud

- API methods
- Administrative tasks for production server
  - CI/CD
  - Server infrastructure

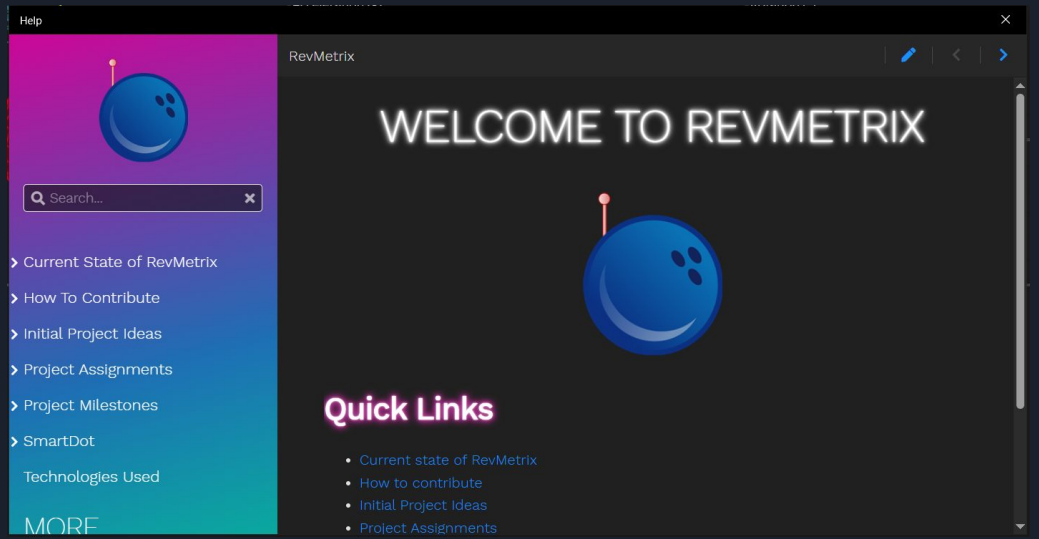
BSA Frontend

- Interface with Ball Spinner Controller and Cloud
  - Cloud - save and load users, shots and arsenal
  - Controller - communicate data regarding motor and SmartDot control
- Output of SmartDot sensor data

Wiki

- Accessible via the Help section in the ball spinner app
- Information
  - Project History
  - Milestones
  - Assignments
  - Development Guides

https://docs.revmetrix.io/

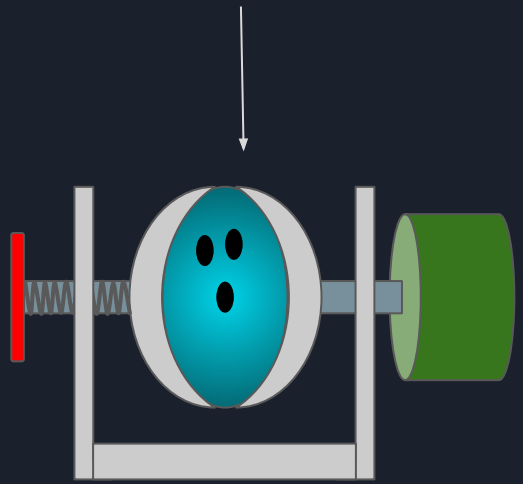


Ball Spinner Controller

- Connects to the BSA Frontend
- Receives commands from the BSA to control the motors at variable speed
- Connects to BTLE Metamotion module and forwards data to the BSA
- Has a Human Machine Interface (HMI)
- Implements a TCP messaging protocol with the BSA

Ball Spinner Team

- Pivoted from wheel spinning design to the new vice design
  - Could not determine no slippage from previous design
  - Roller coefficient of friction too high
- Change in measuring motor input
  - From a light tachometer to an encoder
  - This change can ensure accurate motor recording



Mobile Application Team

- Basic implementation of mobile/ windows app
  - Login/ Register
  - Page navigation
  - Account Edit
  - Page Frameworks
- Basic database implementation
  - User
  - Ball

Questions?

Technologies Used

Application

- .NET, .NET MAUI
- OpenTK(Three.JS)
- Livecharts2(Chart.JS)
- xUnit

Cloud

- .NET
- xUnit
- Docker
- Digital Ocean
- Github Actions

Ball Spinner Controller

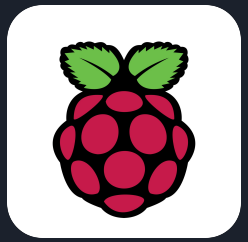
- Raspberry Pi
- Tina Cloud

Ball Spinner

- SolidWorks
- Onshape

Cellular

- .NET MAUI
- SQLite

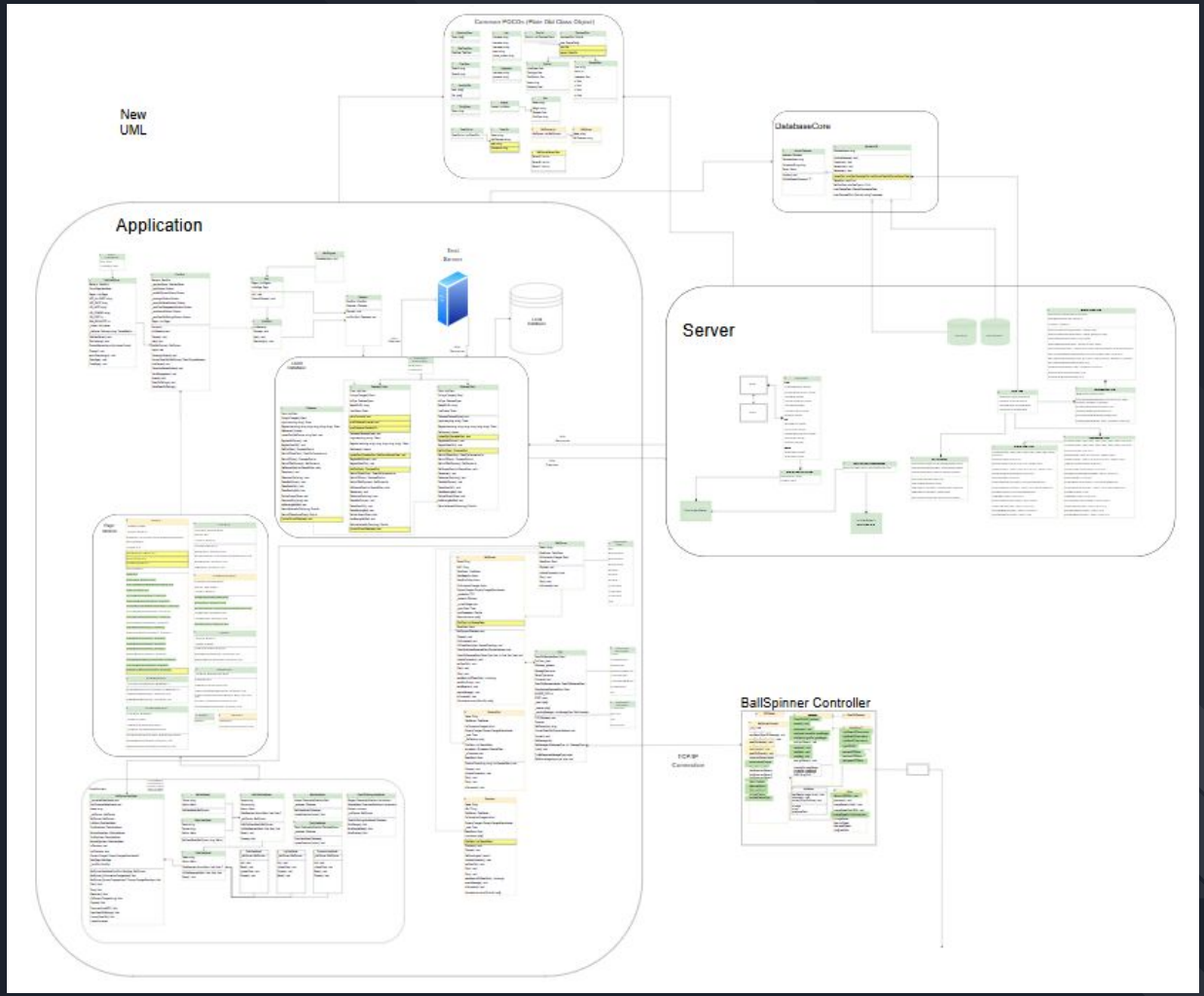


Current Design

Implemented

Partially Implemented

Not Yet Implemented

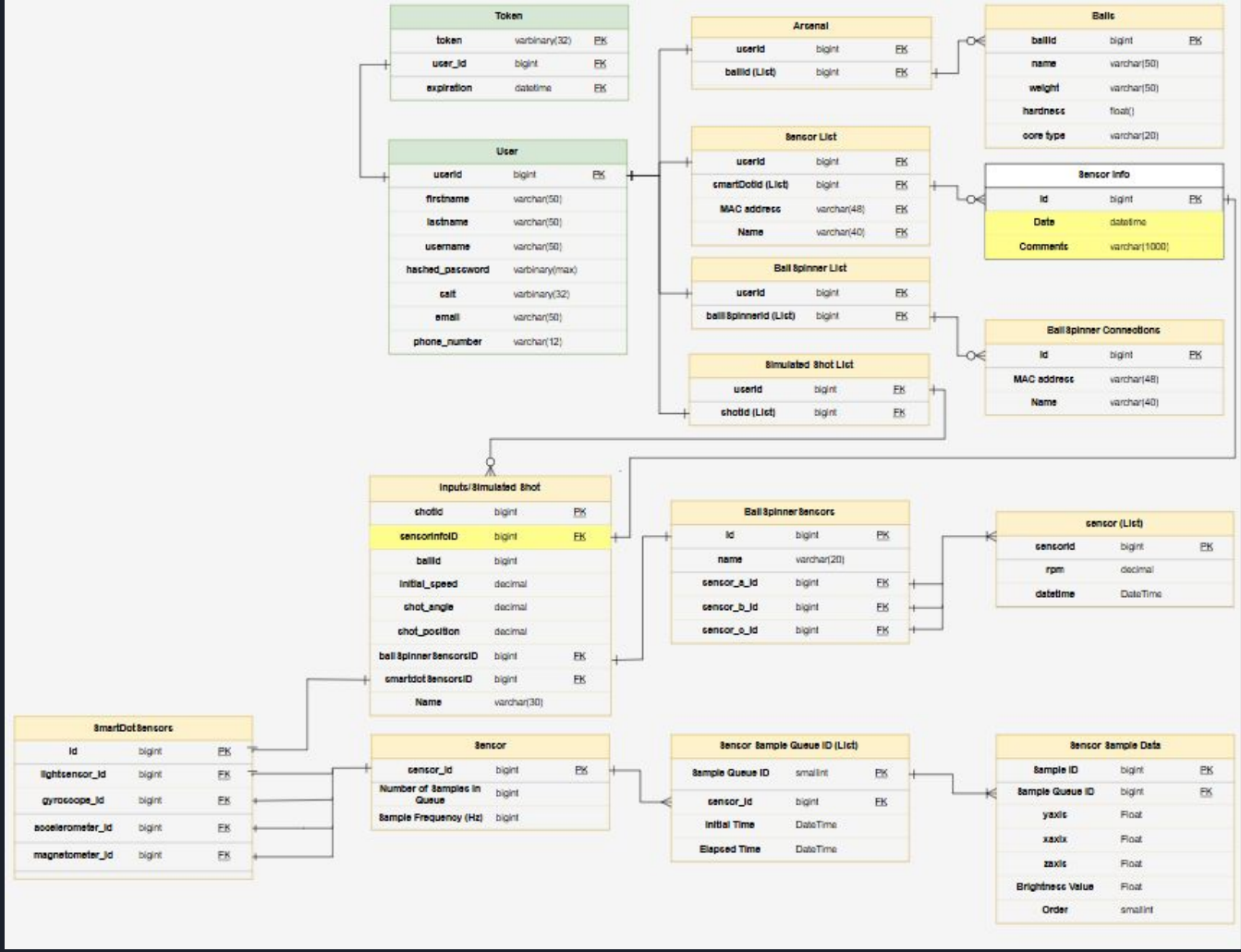


Current Database Schema BS

Implemented

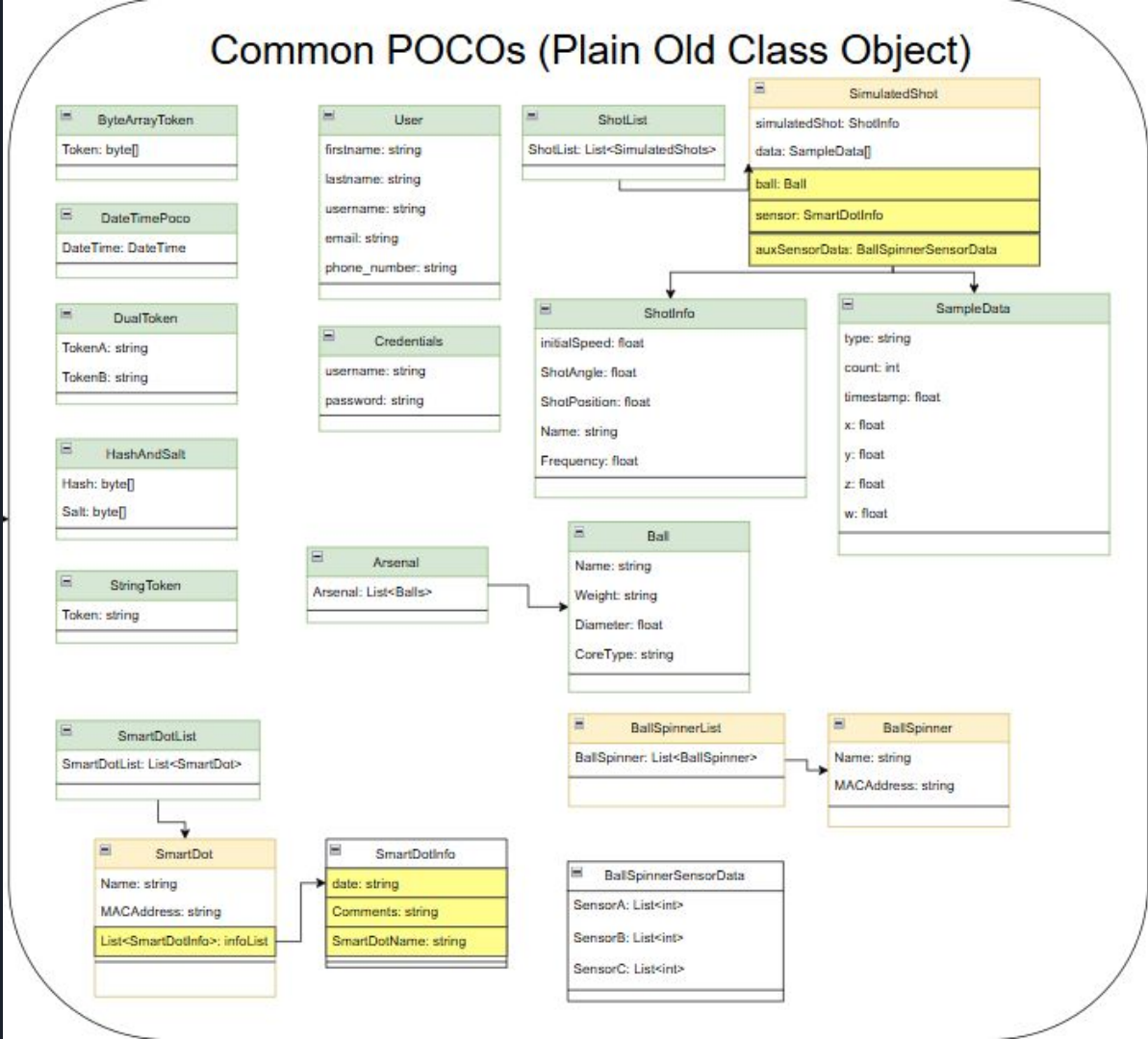
Partially Implemented

Not Yet Implemented

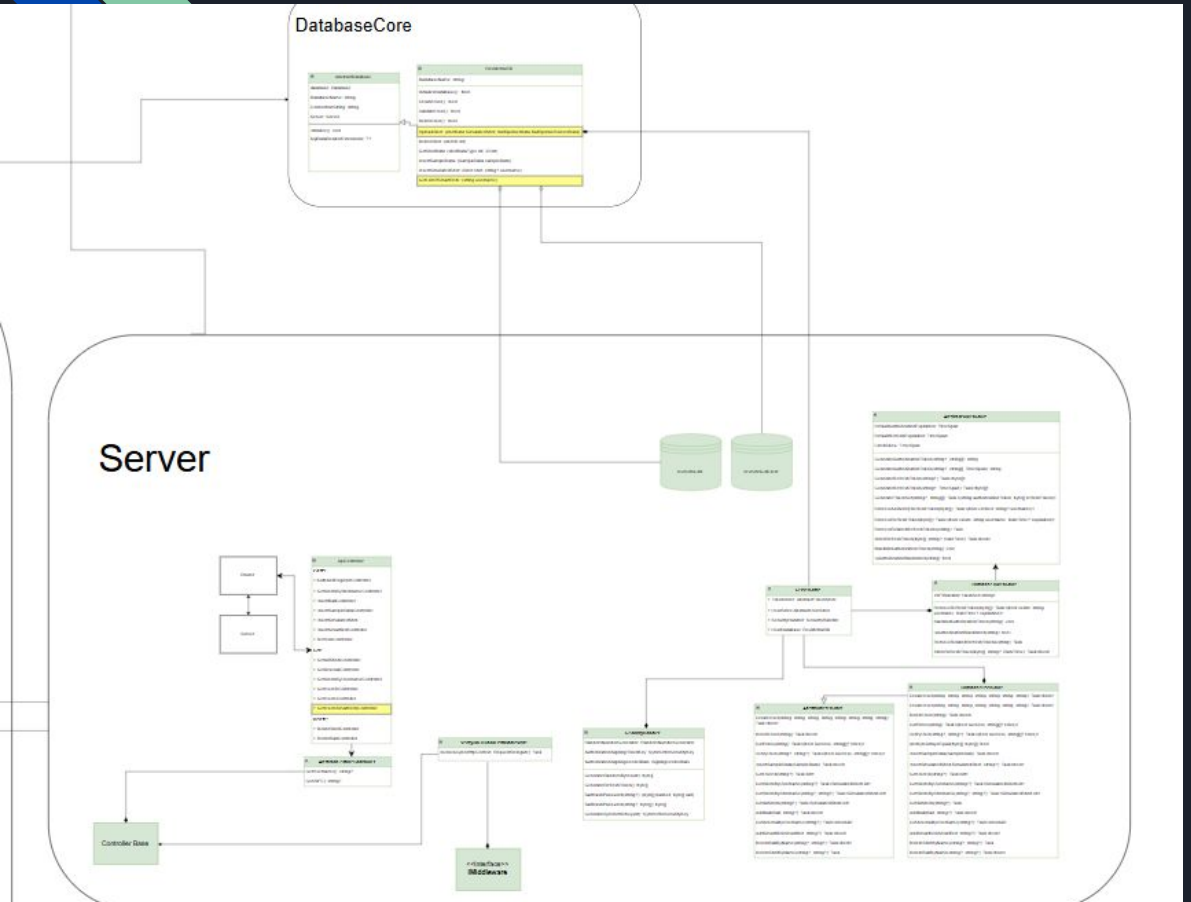


Current Design

POCOs

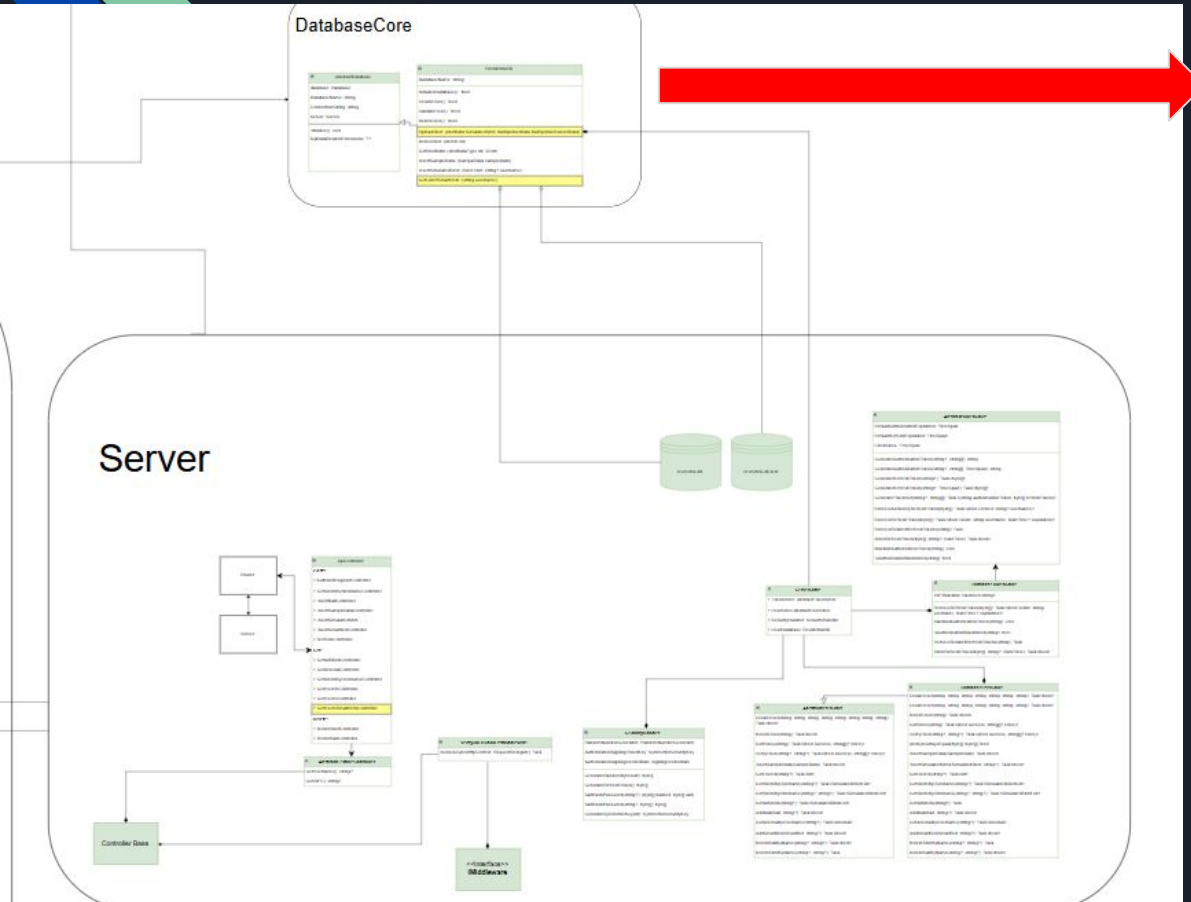

Common POCOs (Plain Old Class Object)
ByteArrayToken
Token: byte[]
DateTimePoco
DateTime: DateTime
DualToken
TokenA: string
TokenB: string
HashAndSalt
Hash: byte[]
Salt: byte[]
StringToken
Token: string
User
firstname: string
lastname: string
username: string
email: string
phone_number: string
Credentials
username: string
password: string
ShotList
ShotList: List<SimulatedShots>
SimulatedShot
simulatedShot: ShotInfo
data: SampleData[]
ball: Ball
sensor: SmartDotInfo
auxSensorData: BallSpinnerSensorData
ShotInfo
initialSpeed: float
ShotAngle: float
ShotPosition: float
Name: string
Frequency: float
SampleData
type: string
count: int
timestamp: float
x: float
y: float
z: float
w: float
Arsenal
Arsenal: List<Balls>
Ball
Name: string
Weight: string
Diameter: float
CoreType: string
SmartDotList
SmartDotList: List<SmartDot>
SmartDot
Name: string
MACAddress: string
List<SmartDotInfo>: infoList
SmartDotInfo
date: string
Comments: string
SmartDotName: string
BallSpinnerList
BallSpinner: List<BallSpinner>
BallSpinner
Name: string
MACAddress: string
BallSpinnerSensorData
SensorA: List<int>
SensorB: List<int>
SensorC: List<int>

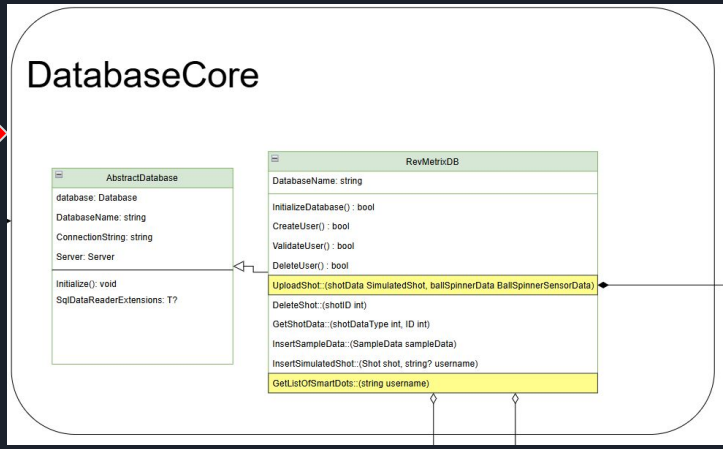
Cloud



Current Design

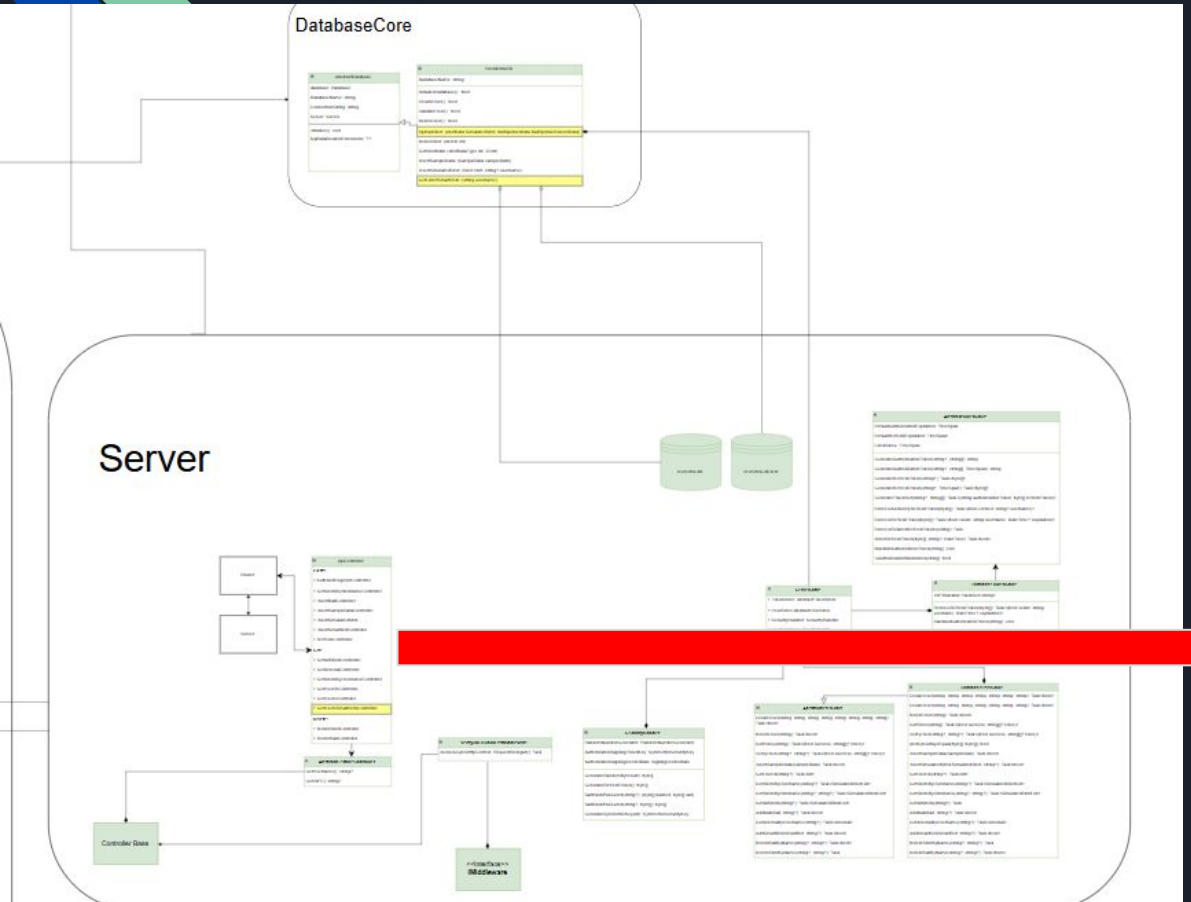
Cloud





Current Design

Cloud



ApiController

Posts

+ AuthAndRegisterController
+ GetShotsByShotnameController
+ InsertBallController
+ InsertSampleDataController
+ InsertSimulatedShot
+ InsertSmartDotController
+ RefreshController

Get:

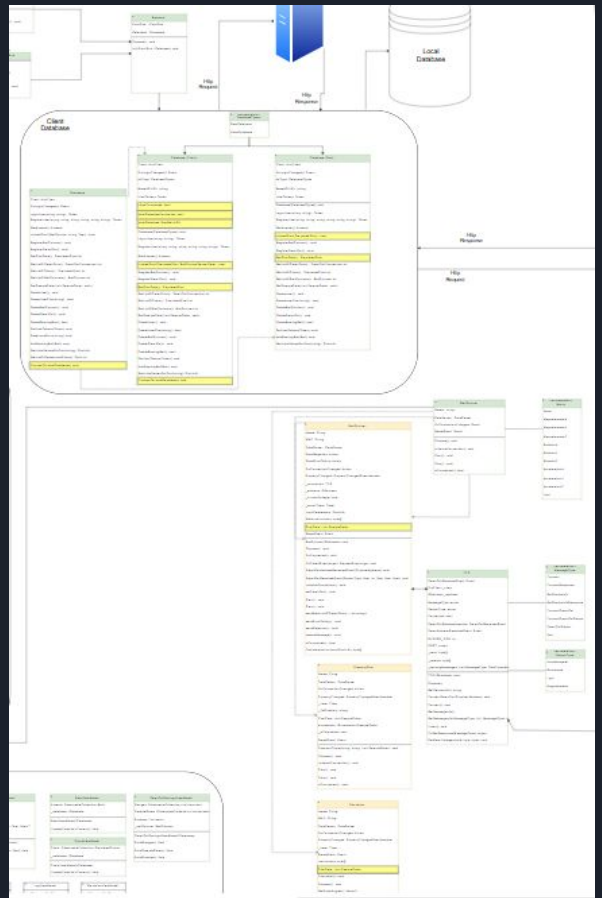
+ GetAllShotsController
+ GetArsenalController
+ GetShotsByUsernameController
+ GetUserIDController
+ GetUsersController
+ GetUsersSmartDotsController

Delete:

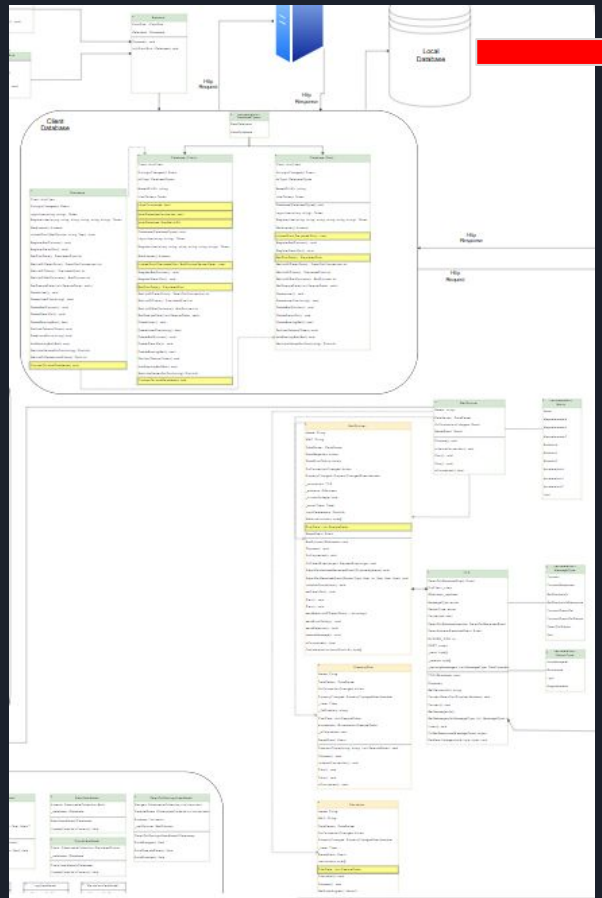
+ DeleteShotController
+ DeleteBallController

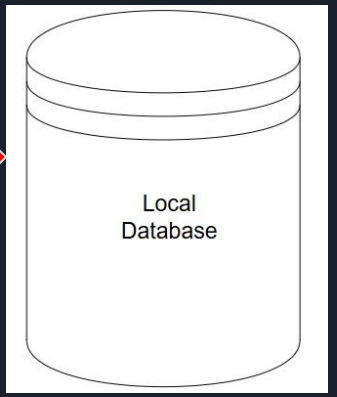
Current Design

BSA Backend

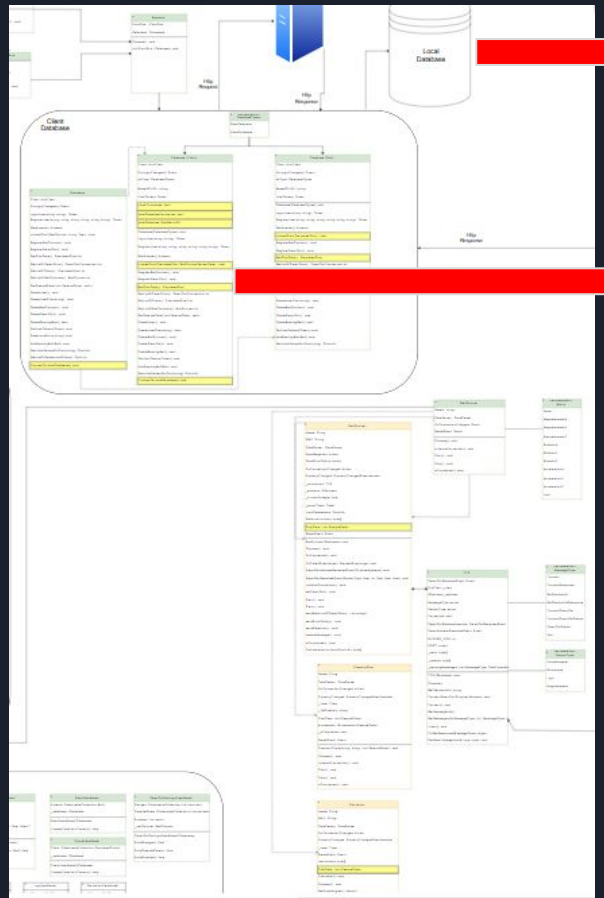

Local Database
Client Database
Http Request
Http Response

BSA Backend

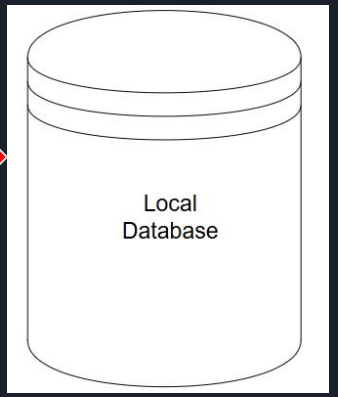




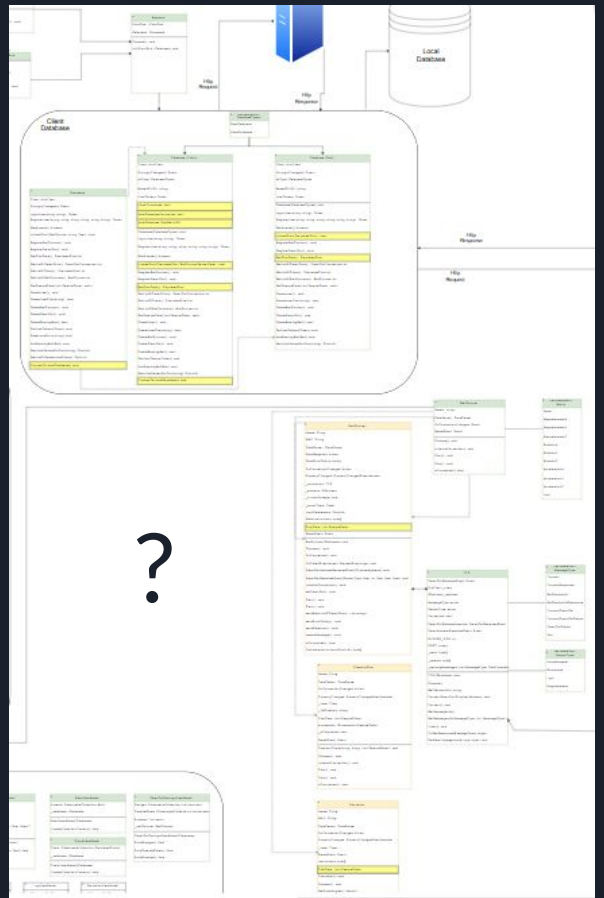
BSA Backend

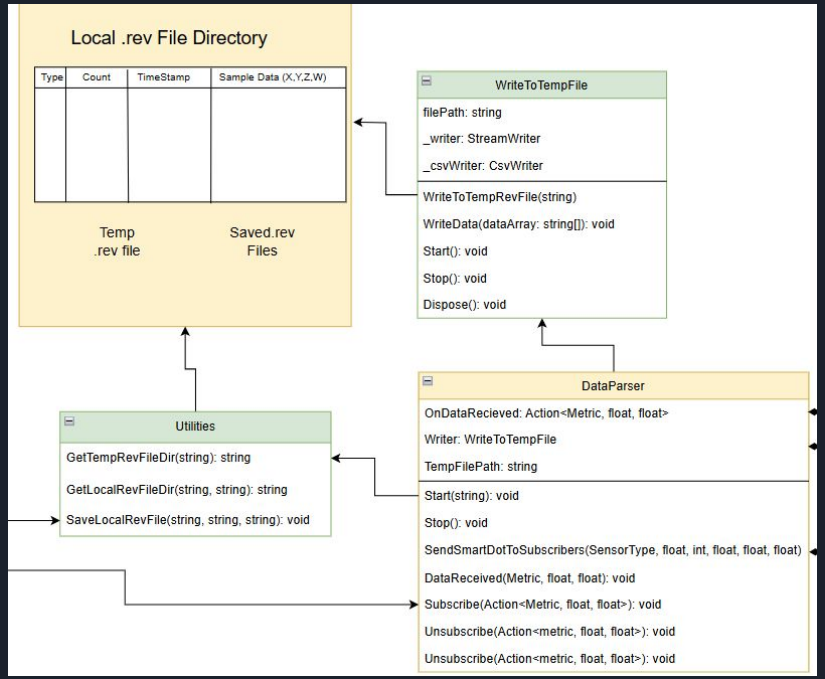


Database (Client)
Client: HttpClient
OnLoginChanged(): Event
dbType: DatabaseTypes
BaseAPIURL: string
UserTokens: Token
cloudConnected: bool
localDatabaseConnected: bool
localDatabase: RevMetrixDb
Database(DatabaseTypes): void
LoginUser(string, string) : Token
RegisterUser(string, string, string, string, string, string) : Token
GetArsenal(): Arsenal
UploadShot(SimulatedShot, BallSpinnerSensorData) : bool
RegisterBallSpinner() : void
RegisterSmartDot() : void
GetShotData() : SimulatedShot
GetListOfSmartDots() : SmartDotConnectionList
GetListOfShots() : SimulatedShotList
GetListOfBallSpinners() : BallSpinnerList
GetSampleData(List<SampleData>, path)
DeleteUser() : void
DeleteUserShot(string) : bool
DeleteBallSpinner() : void
DeleteSmartDot() : void
DeleteBowlingBall(): bool
SetUserTokens(Token): void
AddBowlingBall(Ball): bool
GetInitialValuesForShot(string): ShotInfo
ConnectToLocalDatabase(): void

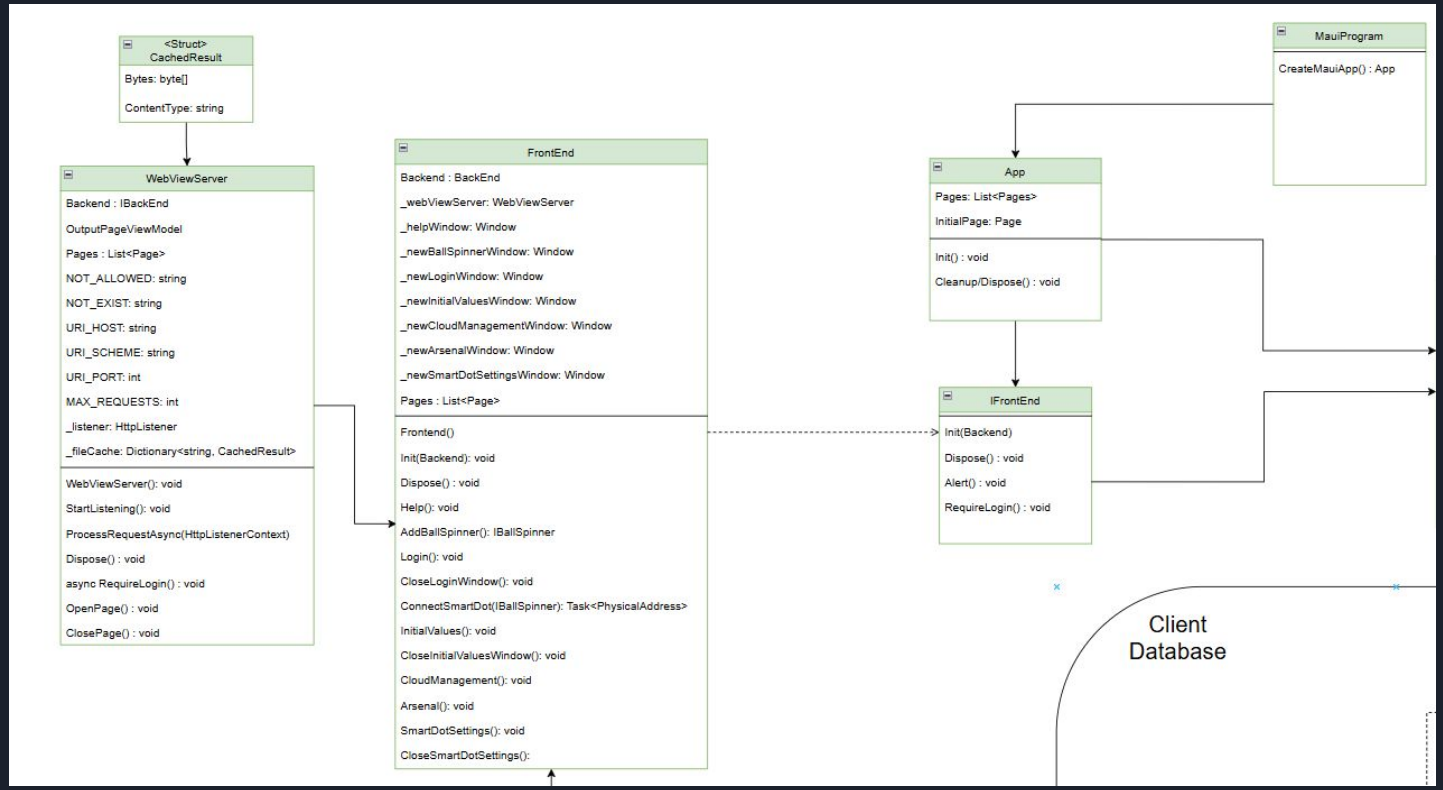


BSA Backend

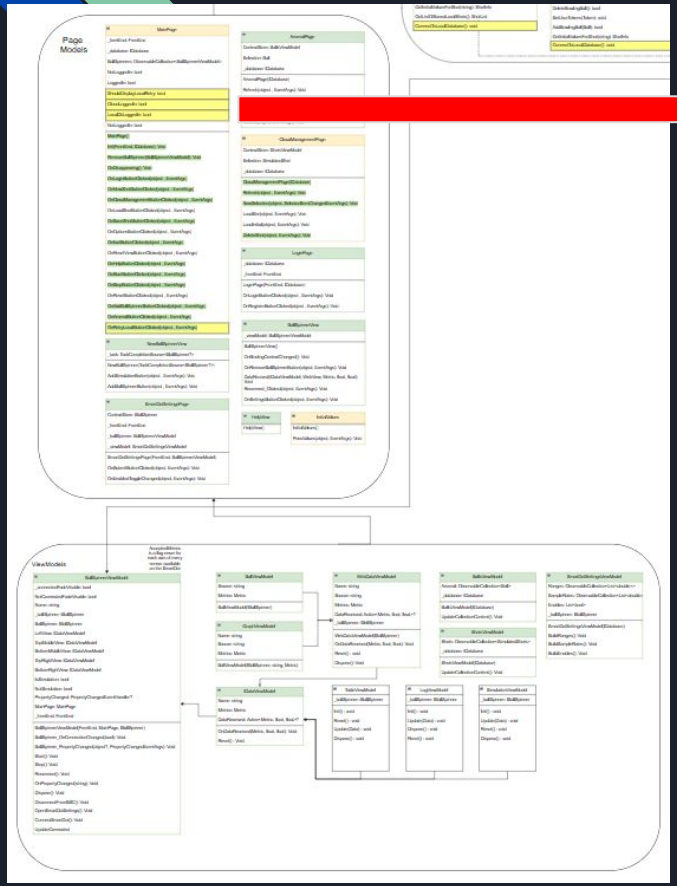

Local Database
Client Database
?


Local .rev File Directory
Type
Count
TimeStamp
Sample Data (X,Y,Z,W)
Temp .rev file
Saved.rev Files
WriteToTempFile
filePath: string
_writer: StreamWriter
_csvWriter: CsvWriter
WriteToTempRevFile(string)
WriteData(dataArray: string[]): void
Start(): void
Stop(): void
Dispose(): void
DataParser
OnDataRecieved: Action<Metric, float, float>
Writer: WriteToTempFile
TempFilePath: string
Start(string): void
Stop(): void
SendSmartDotToSubscribers(SensorType, float, int, float, float, float)
DataReceived(Metric, float, float): void
Subscribe(Action<Metric, float, float>): void
Unsubscribe(Action<metric, float, float>): void
Unsubscribe(Action<metric, float, float>): void
Utilities
GetTempRevFileDir(string): string
GetLocalRevFileDir(string, string): string
SaveLocalRevFile(string, string, string): void

BSA Frontend



BSA Frontend



MainPage

_frontEnd: FrontEnd

_database: IDatabase

BallSpinners: ObservableCollection<BallSpinnerViewModel>

NotLoggedIn: bool

LoggedIn: bool

ShouldDisplayLocalRetry: bool

CloudLoggedIn: bool

LocalDbLoggedIn: bool

NotLoggedIn: bool

MainPage()

Init(FrontEnd, IDatabase): Void

RemoveBallSpinner(BallSpinnerViewModel): Void

OnDisappearing(): Void

OnLoginButtonClicked(object , EventArgs)

OnNewShotButtonClicked(object , EventArgs)

OnCloudManagementButtonClicked(object , EventArgs)

OnLoadShotButtonClicked(object , EventArgs)

OnSaveShotButtonClicked(object , EventArgs)

OnOptionsButtonClicked(object , EventArgs)

OnExitButtonClicked(object , EventArgs)

OnResetViewButtonClicked(object , EventArgs)

OnHelpButtonClicked(object , EventArgs)

OnStartButtonClicked(object , EventArgs)

OnStopButtonClicked(object , EventArgs)

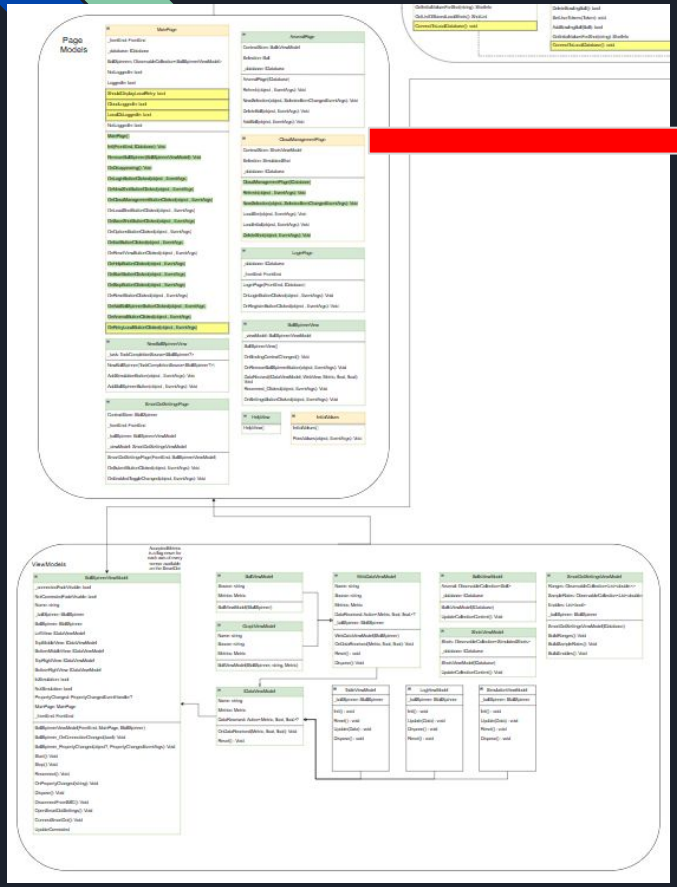
OnResetButtonClicked(object , EventArgs)

OnAddBallSpinnerButtonClicked(object , EventArgs)

OnArsenalButtonClicked(object , EventArgs)

OnRetryLocalButtonClicked(object , EventArgs)

BSA Frontend



ArsenalPage

ContextStore: BallsViewModel

Selection: Ball

_database: IDatabase

ArsenalPage(IDatabase)

Refresh(object , EventArgs): Void

NewSelection(object, SelectedItemChangedEventArgs): Void

DeleteBall(object, EventArgs): Void

AddBall(object, EventArgs): Void

CloudManagementPage

ContextStore: ShotsViewModel

Selection: SimulatedShot

_database: IDatabase

CloudManagementPage(IDatabase)

Refresh(object , EventArgs): Void

NewSelection(object, SelectedItemChangedEventArgs): Void

LoadSim(object, EventArgs): Void

LoadInitial(object, EventArgs): Void

DeleteShot(object, EventArgs): Void

LoginPage

_database: IDatabase

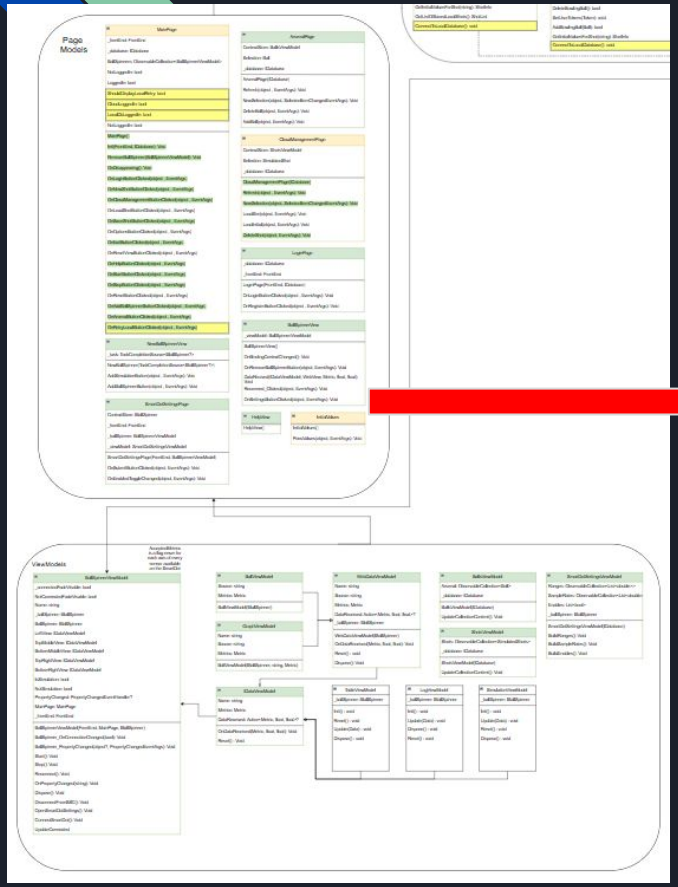
_frontEnd: FrontEnd

LoginPage(FrontEnd, IDatabase)

OnLoginButtonClicked(object , EventArgs): Void

OnRegisterButtonClicked(object , EventArgs): Void

BSA Frontend



OnArsenalButtonClicked(object , EventArgs)

OnRetryLocalButtonClicked(object , EventArgs)

NewBallSpinnerView

_task: TaskCompletionSource<IBallSpinner?>

NewBallSpinner(TaskCompletionSource<IBallSpinner?>)

AddSimulationButton(object , EventArgs): Void

AddBallSpinnerButton(object , EventArgs): Void

SmartDotSettingsPage

ContextStore: IBallSpinner

_frontEnd: FrontEnd

_ballSpinner: BallSpinnerViewModel

_viewModel: SmartDotSettingsViewModel

SmartDotSettingsPage(FrontEnd, BallSpinnerViewModel)

OnSubmitButtonClicked(object, EventArgs): Void

OnEnabledToggleChanged(object, EventArgs): Void

BallSpinnerView

_viewModel: BallSpinnerViewModel

BallSpinnerView()

OnBindingContextChanged(): Void

OnRemoveBallSpinnerButton(object, EventArgs): Void

DataRecived(IDataViewModel, WebView, Metric, float, float): Void

Reconnect_Clicked(object, EventArgs): Void

OnSettingsButtonClicked(object, EventArgs): Void

HelpView

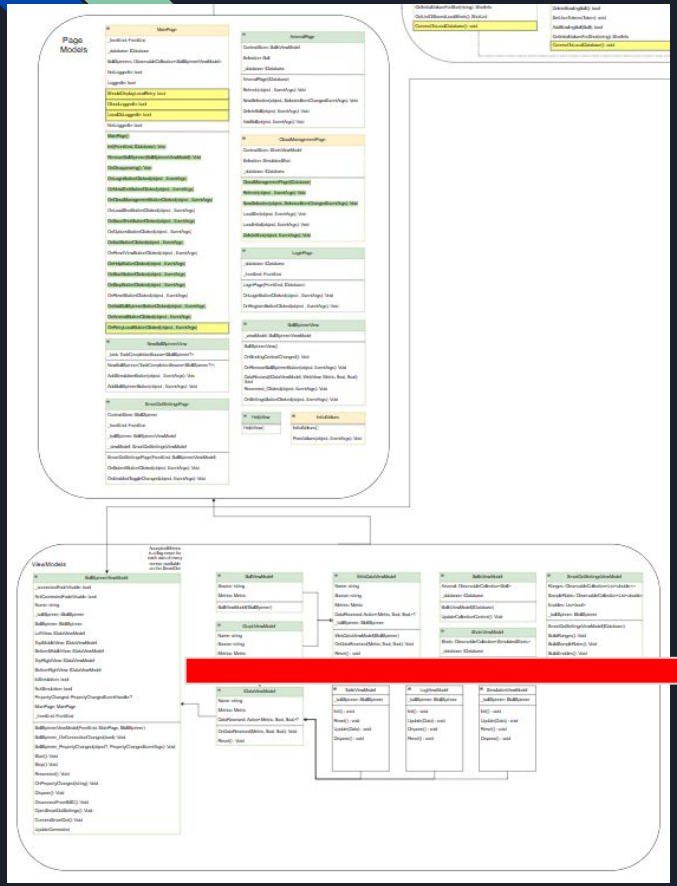
HelpView()

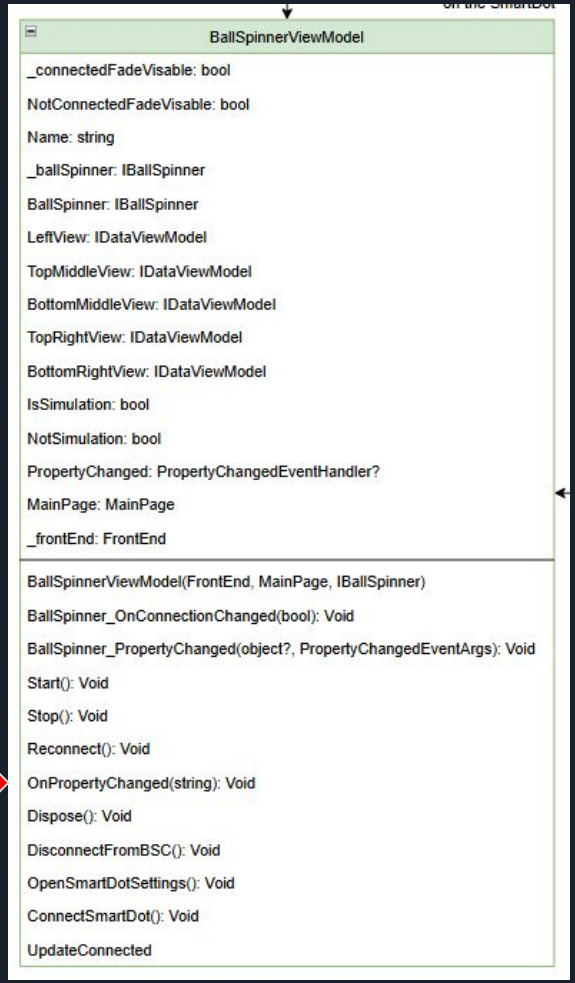
InitialValues

InitialValues()

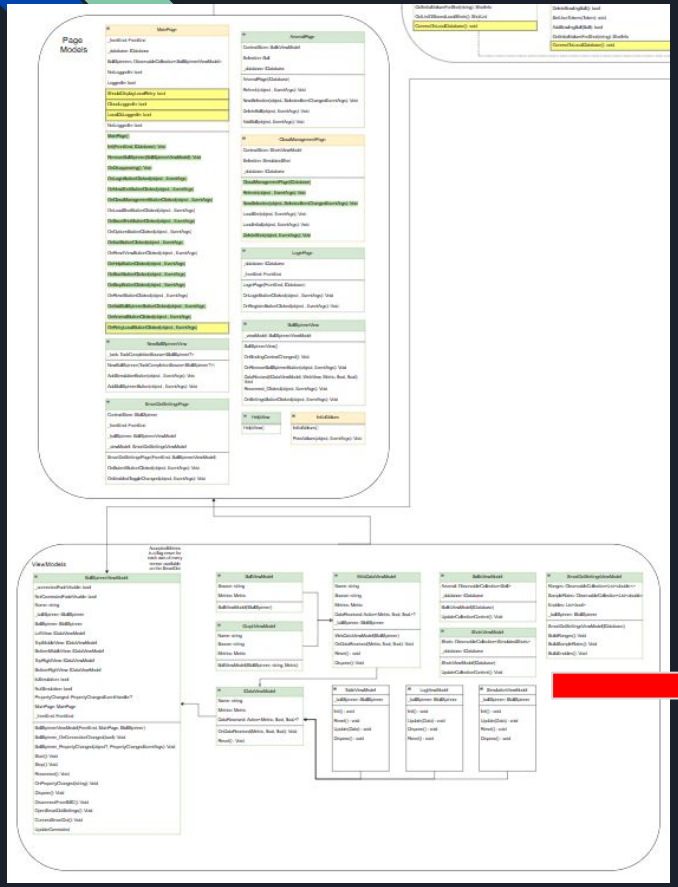
PassValues(object, EventArgs): Void

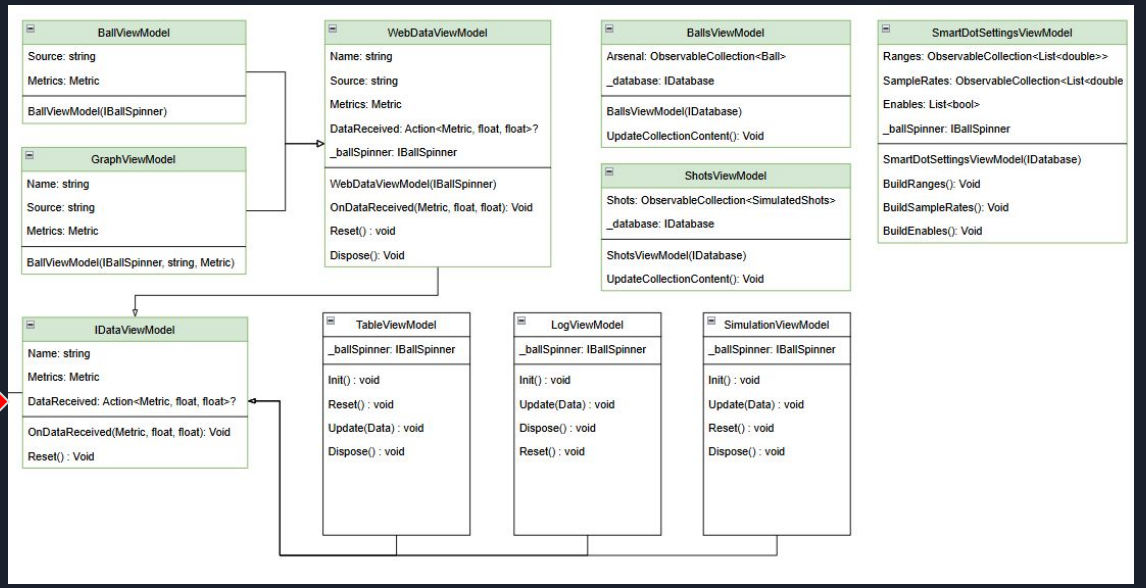
BSA Frontend





BSA Frontend





Protocol

1. Setup Connection Messages

a) A_B_INIT_HANDSHAKE: previously (APP_INIT)

Msg Type (0x01)	Msg Size (0x0001)	Random Start Byte (1 Byte)

b) B_A_INIT_HANDSHAKE_ACK: previously (APP_INIT_ACK)

Msg Type (0x02)	Msg Size (0x0001)	Repeated Random Byte (1 Byte)

c) A_B_NAME_REQ: previously (BSC_NAME_REQ)

Msg Type (0x03)

d) B_A_NAME: previously (BSC_NAME)

Msg Type (0x04)	Msg Size (2 Bytes)	ASCII NAME (Up to 255 Bytes)

2. Setup SmartDot Connection

a) A_B_START_SCAN_FOR_SD: previously (SMARTDOT_SCAN)

Msg Type (0x05)

b) B_A_SCANNED_SD: previously (SMARTDOT_SCAN)

Msg Type (0x06)	Msg Size (2 Bytes)	BLE MAC Address (6 Bytes)	Name in ASCII (Up to 255 Bytes)

c) A_B_CHOSEN_SD

Msg Type (0x07)	Msg Size (2 Bytes)	BLE MAC Address (6 Bytes)	Name in ASCII (Up to 255 Bytes)

d) B_A_RECEIVE_CONFIG_INFO

Msg Type (0x08)	Msg Size (2 Bytes) 0x0008	Accel Sample Rates (2 Byte)	Gyro Sample Rates (2 Byte)	Mag Sample Rates (2 Byte)	Light Sample Rates (2 Byte)

Protocol

3. Sending Run Data

a) A_B_RECEIVE_SD_CONFIG

Msg Type (0x09)	Msg Size (0x0004)	Set Config For SD 2 Bytes

b) A_B_SD_TOGGLE_TAKE_DATA

Msg Type (0x0F)	Msg Size (0x0001)	On or off byte (1 byte)

c) B_A_SD_SENSOR_DATA

Msg Type (0x0B)	Msg Size (0x0013)	Sensor Type (1 Byte)	Sample Count (3 Byte)	Time Stamp (4 Byte)	"X-axis" data (4 Bytes)	"Y-axis" data (4 Bytes)	"Z-axis" data (4 Bytes)

d) A_B_MOTOR_INSTRUCTIONS

Msg Type (0x0C)	Msg Size (0x0003)	Motor1 Speed (1 Byte)	Motor2 Angle (1 Byte)	Motor3 Angle (1 Byte)

4. Terminate Processes

a) A_B_STOP_MOTOR

Msg Type (0x0D)

b) A_B_DISCONNECT_FROM_BSC

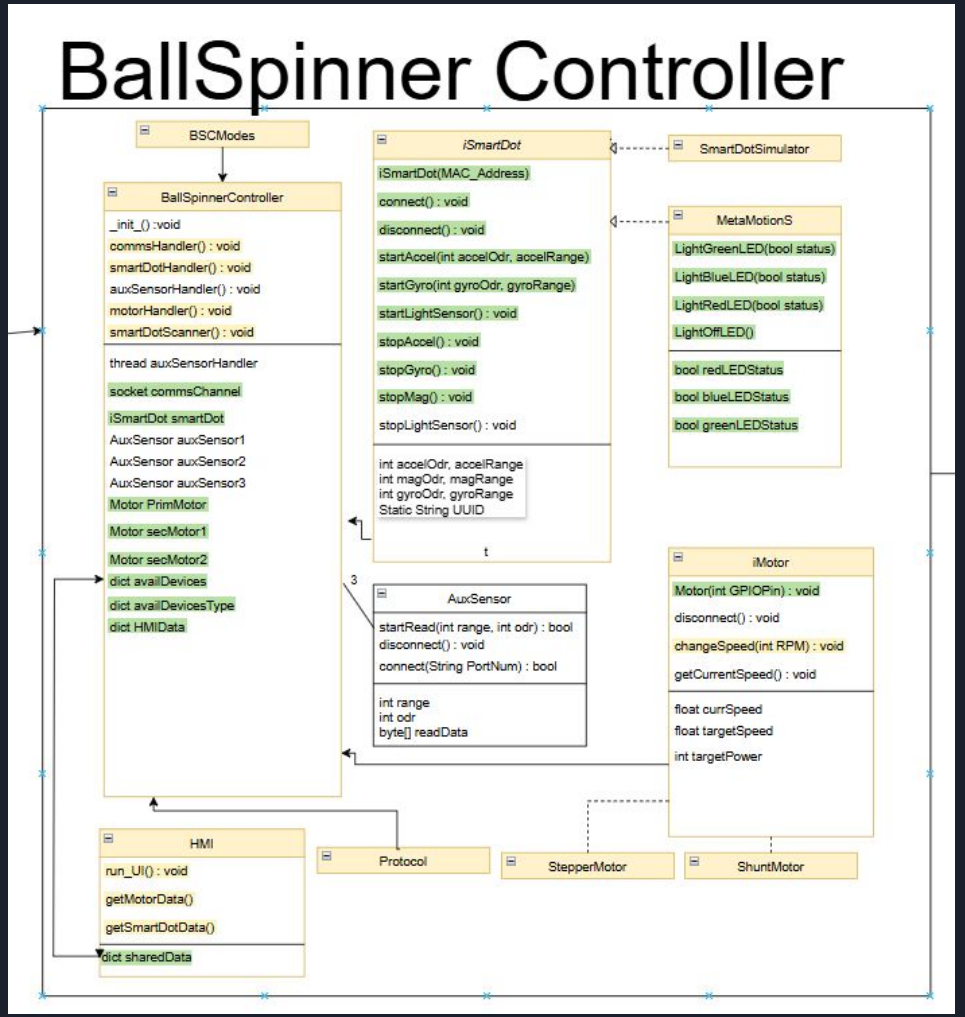
Msg Type (0x0E)

Ball Spinner Controller

Implemented

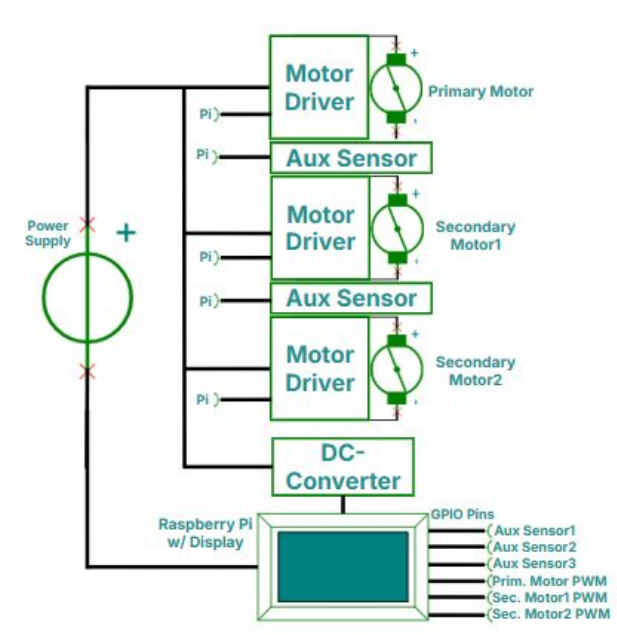
Partially Implemented

Not Yet Implemented

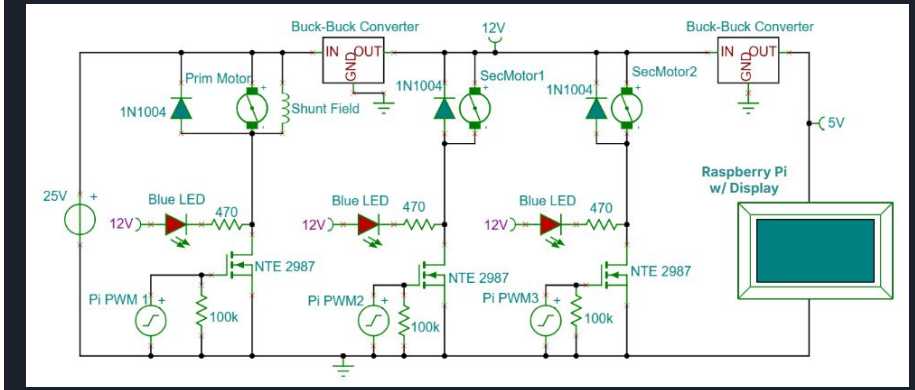


Current Design

Ball Spinner Controller



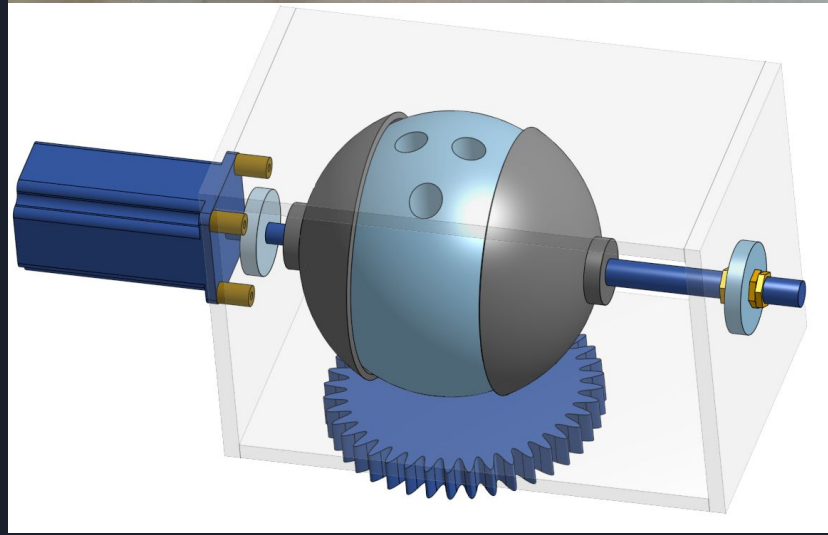
Stepper Motor Electrical Block Diagram



Current Electrical Schematic (using Shunt Motor)

Ball Spinner Team

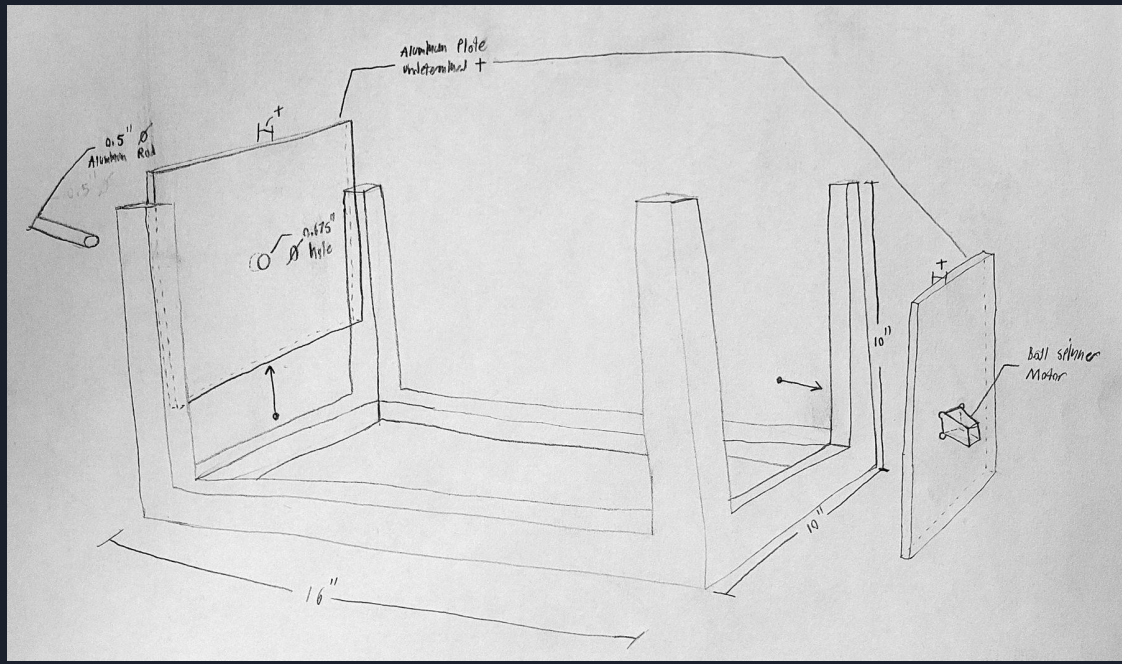
- Prototyped enclosure
  - Serves as temporary housing
  - Used to verify sizing
- Motor selected
- Design modeled
- Axel rod size designed



Current Design

Ball Spinner Team

- Current system dimensions exceed preliminary sketch to provide room to house the motor within the enclosure
    - Also provides greater safety and eases the process of relocating the enclosure when needed.



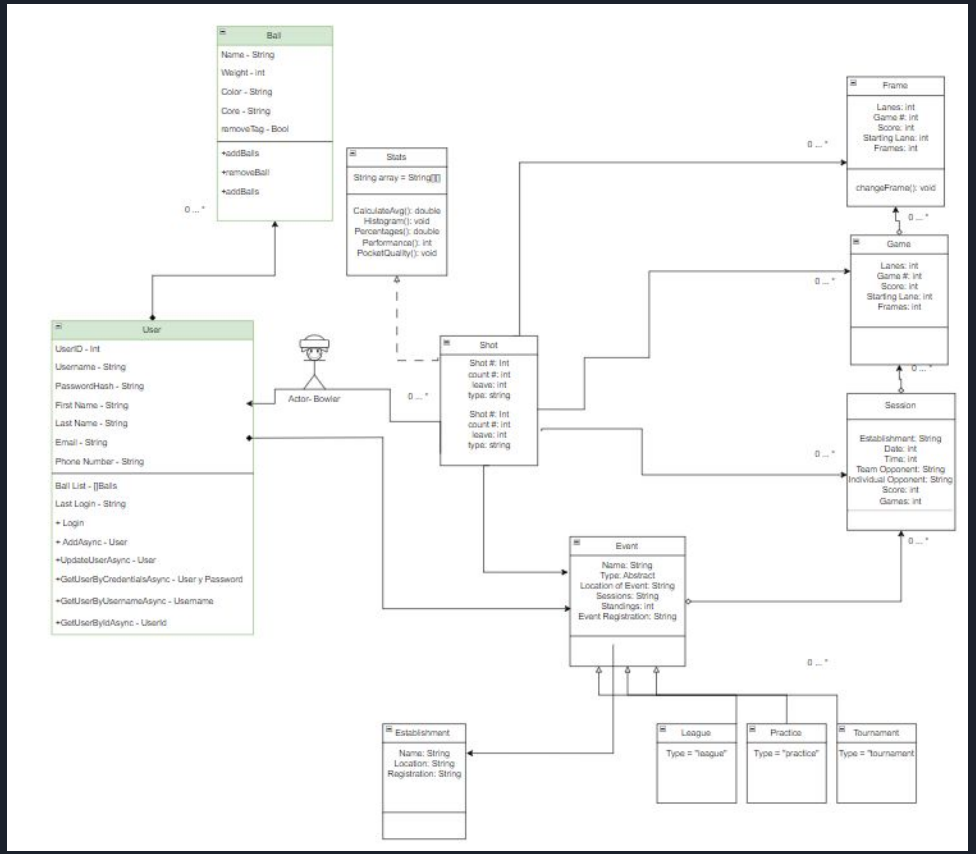
Current Design

Mobile Application Team

Implemented

Partially Implemented

Not Yet Implemented

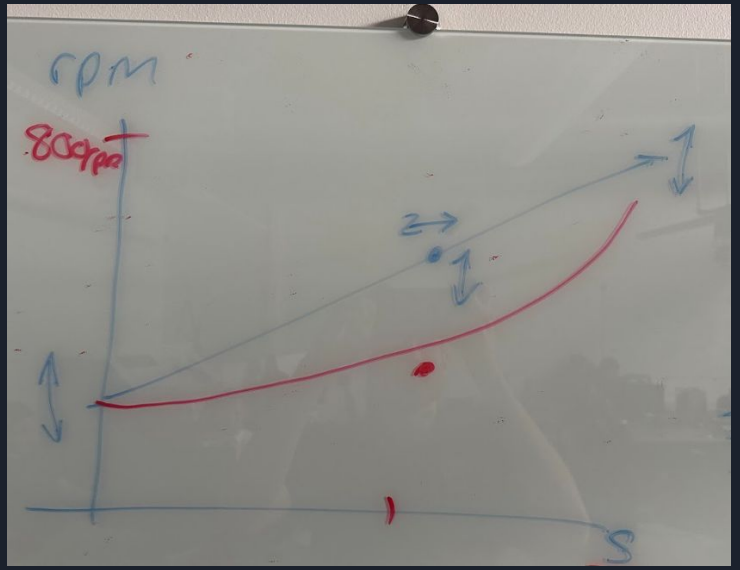


Current Design

Questions?

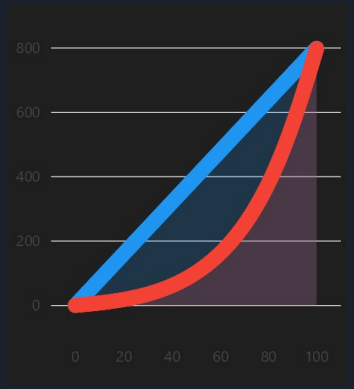
Current Implementation

Simulation (MS1 Goals)

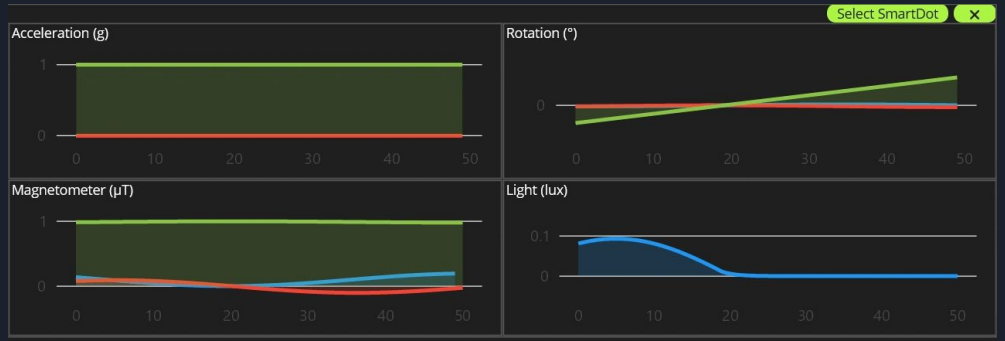


- Replace previous graphics processing with different processes
- See if Unity embedding is feasible, and prototype it
- Get initial values for bezier curve up and showing

Simulation (MS1 Achievements)



- Graphs switched from Chart.JS to LiveCharts2
  - Simpler to embed into MAUI
  - Can be manipulated to get scrollable graphs/draggable graphs and more ambitious ideas quicker
  - Bezier curve graph for initial values up



- Unity prototype implemented in 2 different ways
  - Pop-out/localhost

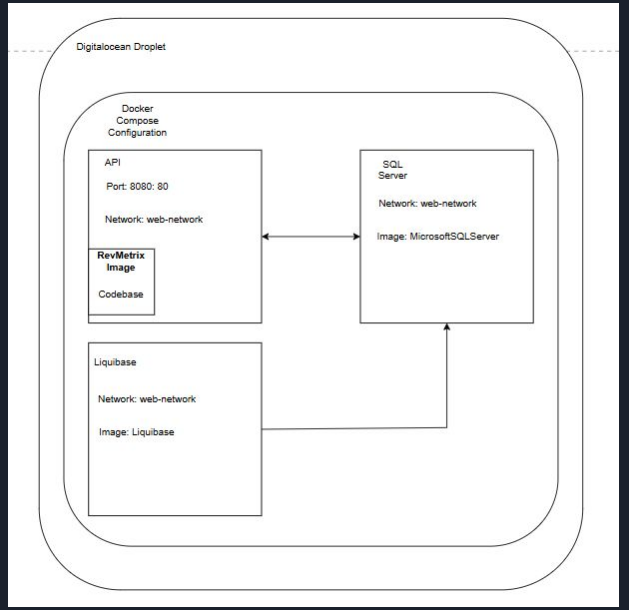
Current Implementation

Database/Backend (MS1 Goals)

- Security will be updated
- Update local dev structure for API server
- Local database for BSA
- Figure out parameters and variables for motor instructions

Database/Backend (MS1 Achievements)

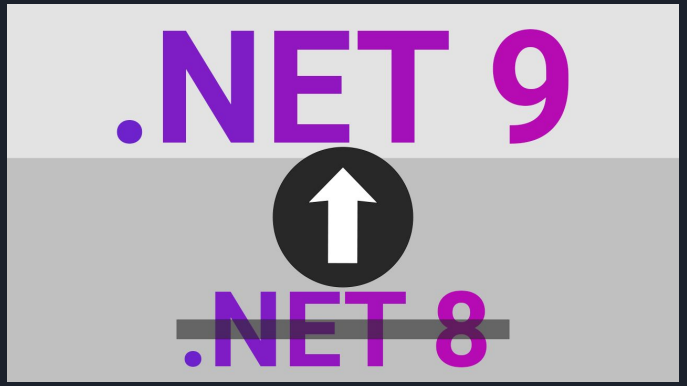
- Cloud Updates
  - API and SQL server communicate through Docker network
  - Liquibase implemented on cloud
- Local Development Updates
  - Docker is used to replicate sql server and liquibase container
  - Local database for Ball Spinner Application using MSSQLLocaldb
- Bug fixed for SmartDot connect screen



Liquibase

Current Implementation

BSA Frontend (MS1 Achievements)



Goals

- Finalize SmartDot Settings Page
- Remove need for Login
- Begin Migrating to .NET 9.0

Achievements

- SmartDot Settings page functional
- Login no longer necessary to use the application
- .NET 9.0 migration

Wiki

MS1 Goals

- Maintain and update the RevMetrix Wiki
- Ensure information is accurate and current
- Assign sections for updates based on project progress
- Reorganize content for clarity and ease of use

MS1 Achievements

- Development environments have been setup
- Familiarizing ourselves with the current state
- Minor reorganization
- Documentation of future additions
- Migration to .NET 9

Protocol Changes

- Renamed All Protocol Messages

  A_B -> From BSA to BSC

  B_A -> From BSC to BSA

- Added Messages
  - Config Messages Bit-Mappings
  - Stop Messages

	XL (Bytes 1 + 2)		GY (Bytes 3 + 4)		MG (Bytes 5 + 6)		LT (Bytes 7 + 8)	
	Bits (7-4)	Bits (3-0)	Bits (7-4)	Bits (3-0)	Bits (7-4)	Bits (3-0)	Bits (7-4)	Bits (3-0)
0x0	12.5 (Hz)	±2	25 (Hz)	125 dps	2 (Hz)	±1300 /2500 (μT)	.5	.01 to 600k (Lux)
0x1	25 (Hz)	±4	50 (Hz)	250 dps	6 (Hz)	X	1	.02 to 1.3k (Lux)
0x2	50 (Hz)	±8	100 (Hz)	1000 dps	8 (Hz)	X	2	.125 to 8k (Lux)
0x3	100 (Hz)	±16	200 (Hz)	2000 dps	10 (Hz)	X	5	.25 to 16k (Lux)
0x4	200 (Hz)	X	400 (Hz)	X	15 (Hz)	X	10	.5 to 32K (Lux)
0x5	400 (Hz)	X	800 (Hz)	X	20 (Hz)	X	20	1 to 64K (Lux)
0x6	800 (Hz)	X	1600 (Hz)	X	25 (Hz)	X	X	X
0x7	1600 (Hz)	X	3200 (Hz)	X	30 (Hz)	X	X	X
0x8	X	X	6400 (Hz)	X	X	X	X	X
0xFF	Do Not Turn On XL	Do Not Turn On XL	Do Not Turn On Gy	Do Not Turn On Gy	Do Not Turn On MG	Do Not Turn On MG	Do Not Turn On LT	Do Not Turn On LT

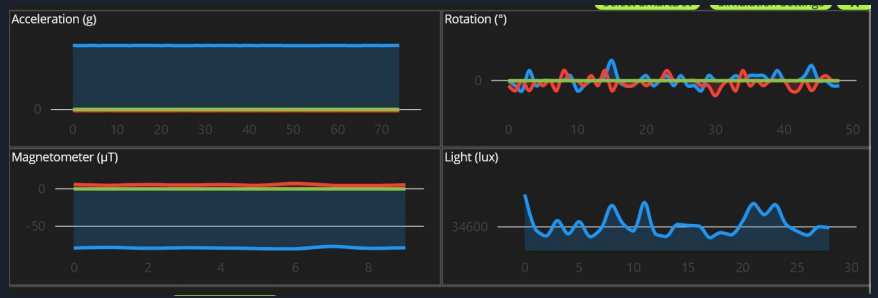
Ball Spinner Controller (MS1 Goals)

- Take Light Sensor Data from MMS
- Allow Application to Configure Smartdot
- Layout GUI

Ball Spinner Controller (MS1 Achievements)

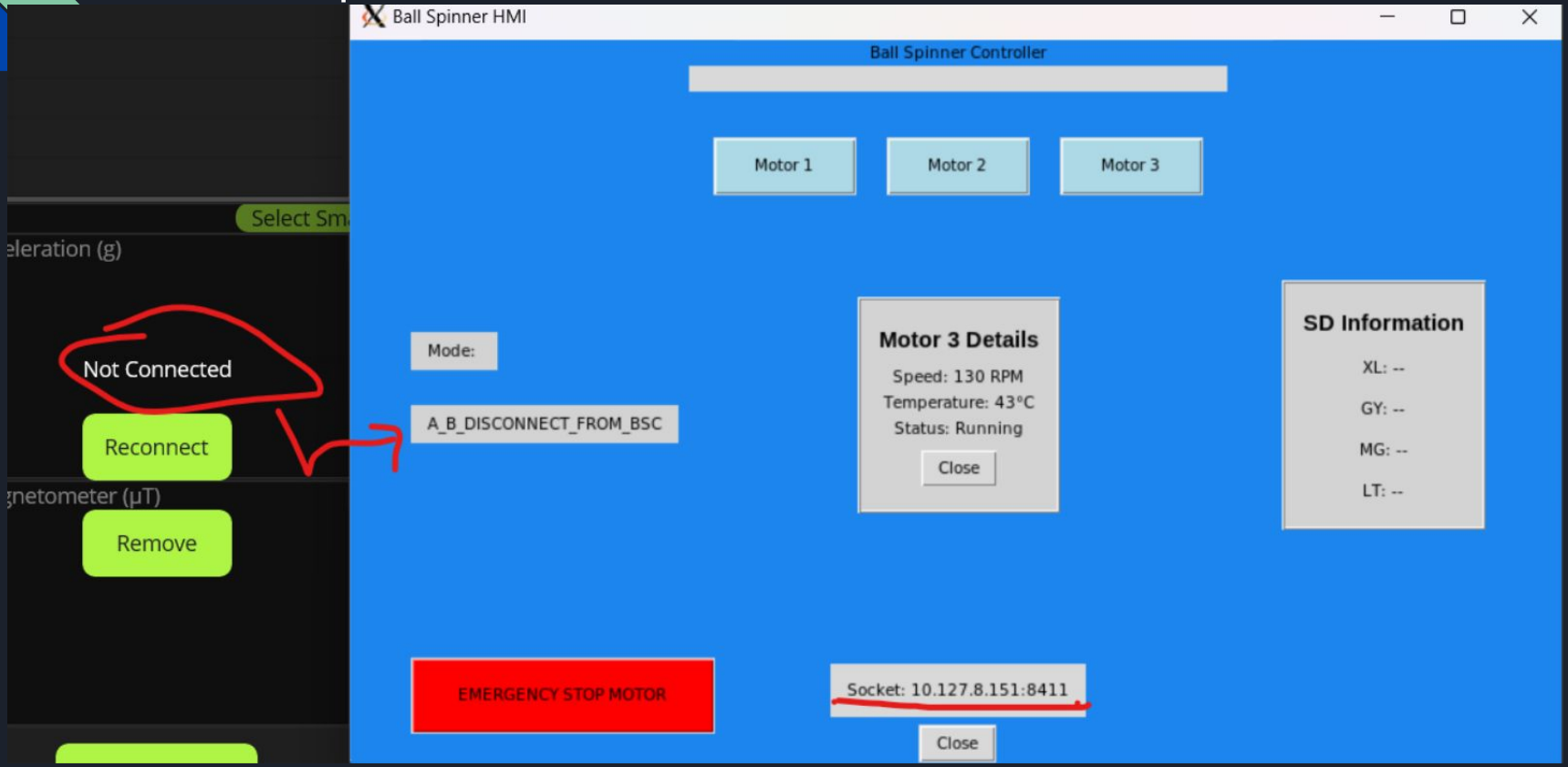
```
Pipe Error Caught in CommsHandler
Socket Closed, must restart
Server listening on 10.127.6.120:8411
```

- Light Sensor Data sent to BSA
- Application can configure Smartdot
- GUI (now referred to as HMI) initial implementation
- Stopped crashing from BSA affecting BSC
- Designed interface with stepper motors



Current Implementation

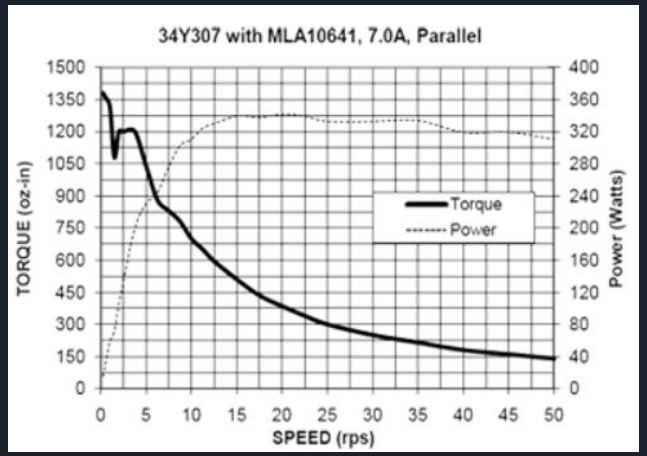
Ball Spinner Controller HMI

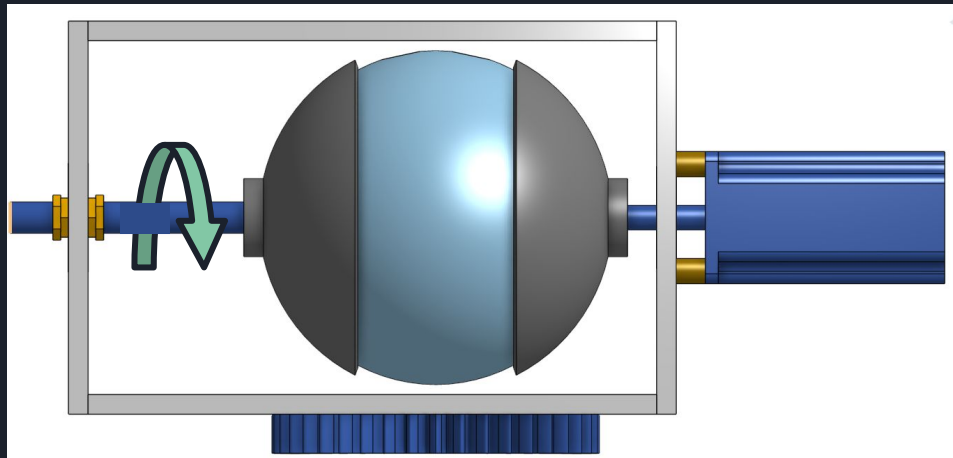


Current Implementation

Ball Spinner Team

- Due to motor torque curves the table shows what is required to drive the ball about the major spin-axis
  - Given that it accelerates over 150 ms





Weight (lbs)	6	16
Torque (oz-in)	760	1030
Peak RPM (direct drive)	540	276
Clamping force required (lbs)	9	12.2
Power (W)	35.8	48.5

Current Implementation

Ball Spinner Team

Proposal

- Have a working motor
- Design primary system
- Design motor interface
- Successfully measure motor input

Reality

- Have a working motors for both the primary and secondary axis
- Designed the majority of the primary system in CAD
- Have not *fully* designed motor interface
- Just received primary motor system
  - Tested how to control stepper motors
  - Acquired an encoder to use with the motor.
- Sourced components to build frame/enclosure
- Got a dedicated space in the workshop

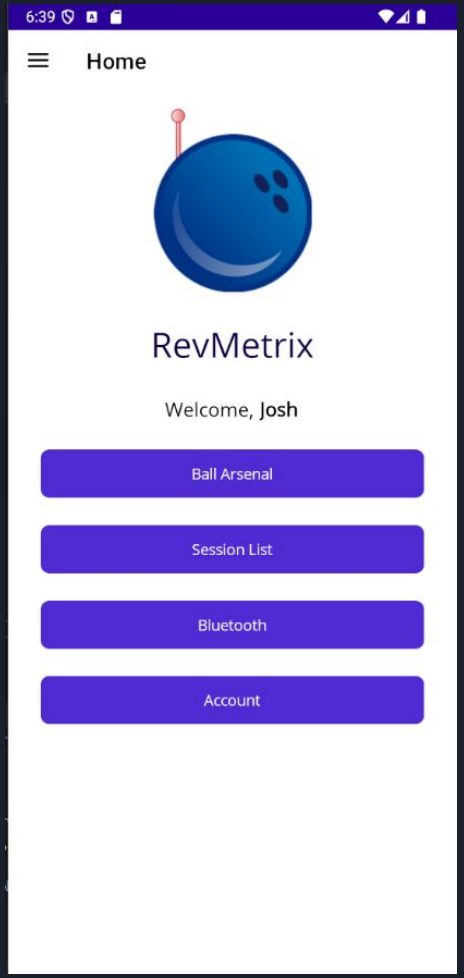
Mobile Application Team

MS1 Goals

- Page framework mostly completed
- Local database implementation

MS1 Achievements

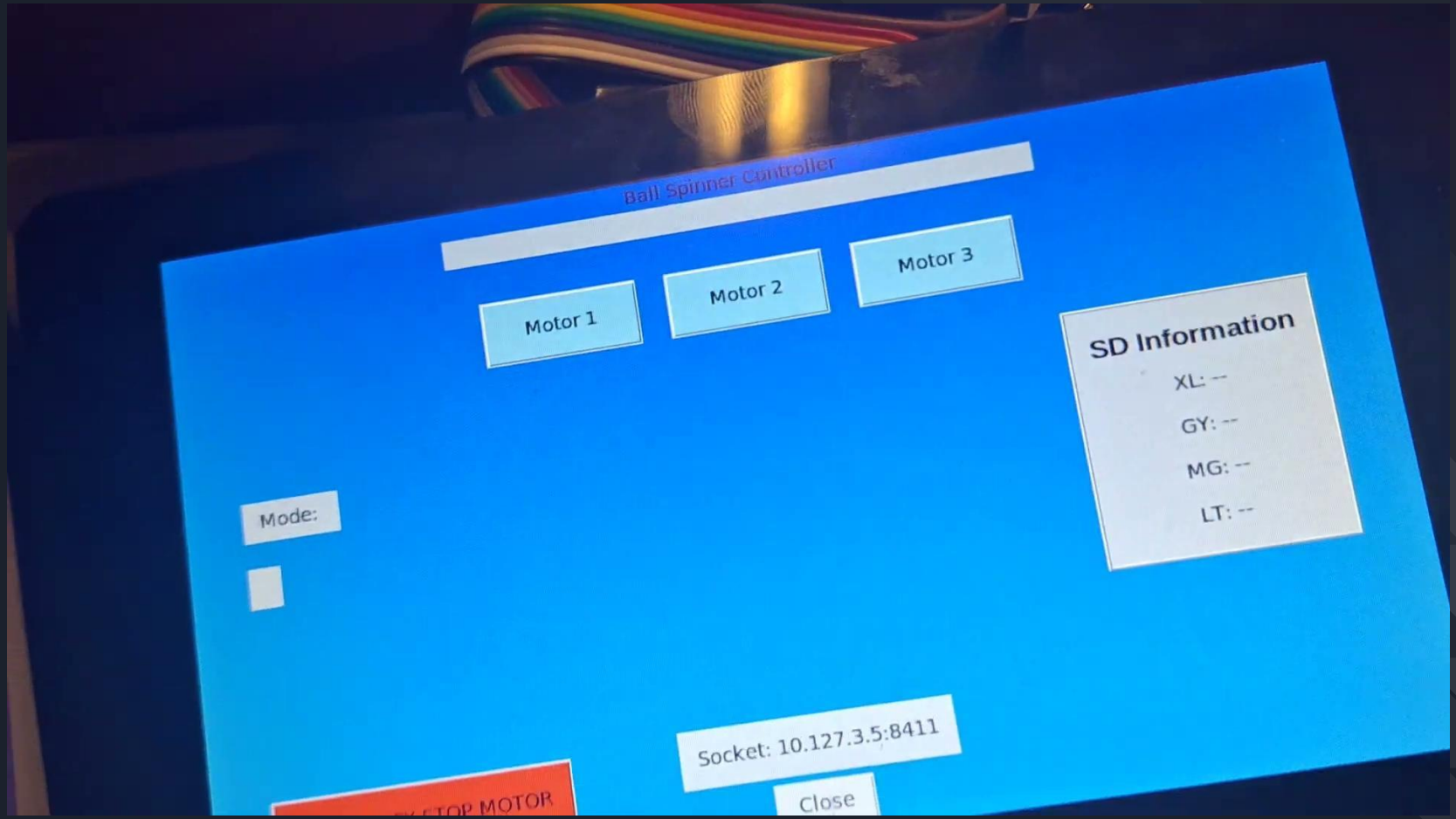
- Core pages basic implementation
- Local Database
  - User Data
  - Ball Data
  - No Cloud Connection
- MAUI knowledge base expanded
  - Critical Areas
- User Interaction
  - Account, Dummy arsenal, player list, frames, and session



Current Implementation

Questions?

Demos


Ball Spinner Controller
Motor 1
Motor 2
Motor 3
SD Information
XL: --
GY: --
MG: --
LT: --
Mode:
Socket: 10.127.3.5:8411
Close

Cellular

Home

RevMetrix

Login

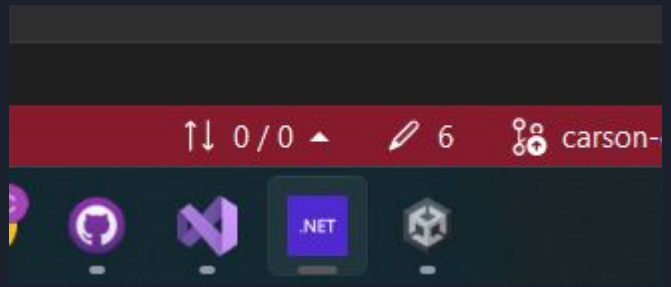
Register

Guest

Future Implementations

Simulation

- Implement OpenTK for the ball visualization
- Improve graphs
  - X axis
  - Sizing
  - Scrolling
  - Bezier sliders
- Update the Unity game to work with the current version of MAUI
- Move forward with the Unity prototype
  - Embed (Localhost) or Popout (EXE)?



Cloud/BSA Backend

- Send motor instructions to BSC
- Client-side/server-side API endpoints
  - Upload shot changes
  - Get list of sensors/sensor information
- CI/CD Updates
  - Automating schema changes with Liquibase
  - Tests
  - Updating nuget packages
- Local BSA database
  - Cloud backup feature
  - Automating local schema changes

BSA Frontend

- Implementation of new graphs/graph functionality
- Support Simulation Team with implementing unity embed
- Support Simulation Team with new implementation of initial values page
- Support Backend Team with further implementation of local db

Wiki

- Improve navigation/ page layouts
- Update development setup instructions
- Document bugs/ fixes
- Add the new mobile app

Ball Spinner Controller

- Interface w/ motor encoders
- PCB and Housing Designs
- Interface w/ Amperage Sensors
- Protocol Messages for Error Messages Drafted

Ball Spinner Team

- Manufacture axle rods
- Modify dimensions of current enclosure
- Size plates to house axle and motor
- Affix free-spinning axle to plate
- Research casting methods for polyurethane cups
- Creating a motor dampening support stand
- Assembly of prototype

Mobile Application Team

- Game functionality
- Establishment page
- Expand Local database
  - Establishments, Sessions, Games, Shots
- Bluetooth connectivity
  - Smart Dot Connection
- Connection to cloud database

Questions?

Many!

Please let Robert Fields graduate on May 17, 2025

Please let this be a normal field trip