Project Specification Document
Microsoft - Power BI Accelerator for Azure FarmBeats
NDSU Capstone 2020

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1.   Project Vision and Objectives

1.1   Project Scope and Vision

Microsoft is utilizing its Azure platform to aggregate farming data from various sensors and satellite imaging. They then want to leverage their embedded Power BI analytics tools to organize and display this farming data in a way that is easy to use and easily readable. They also wanted to implement the built in AI from Azure to allow the application to make projections on future yield and other useful projections. They are calling this project FarmBeats, and it is a Microsoft Azure package. This package is an API that allows users to tailor their application to their needs.

We have been tasked with creating a new application template for FarmBeats that primarily uses Power BI embedded data visualization. To do this we will be creating template web, mobile, and desktop apps for the platform. These apps should be meet the needs of the NDSU Precision Ag department, so that they can be used with their coursework and research. We will be doing this by creating a web API and then implementing it into the various apps.

1.2   Project Goals and Objectives

#	Goal or Objective
1	Generate an Azure Active Directory and set up the environment
2	Use Power BI to create a set of tables and charts
3	Create a web API and embed the Power BI analytics
4	Create web, mobile, and desktop applications using the web API
5	Make sure these applications meet the needs of the NDSU Precision Ag department. They are to be used to aid their classwork/research.
6	Learn about Azure ML
7	Implement Azure ML to generate predictions based on current data

2.   Project Planning

2.1   Project Lifecycle

The project team plans to use an Agile approach, with four sprints of 3 weeks each. The first sprint will focus on defining requirements, creating a high-level development plan, researching Azure, FarmBeats, and Power BI, as well as setting up the required environments. The remaining three sprints will be used to implement gathered requirements according to their priority.

Project schedule will be as follows:
- 1/21 – 2/7 – Sprint 1 –Project Startup
  - Initiation, Planning, Setup
- 2/8 – 3/6 – Sprint 2 – First delivery
  - Req./Code/Test/**Mid-term Presentation**
- 3/7 – 4/6 – Sprint 3 – Second delivery
  - Including updates to documents from Sprint 2
- 4/7 – 5/8 – Sprint 4 – Final Delivery
  - **Final presentation**, Closure/Postmortem

2.2   Project Setup

#	Decision Description
1	Microsoft Teams - Documentation version control and communication
2	Azure DevOps - Code version control
3	Azure Active Directory - All team members must have an account unrelated to NDSU.
4	Embed Power BI into the Azure directory
5	Use Visual Studio to create a web API

2.3   Stakeholders

Stakeholder	Role
Dave Froslie	Mentor
Nicole Haugen	Microsoft team member
Jon Walker	Microsoft team member
Matt Schumacher	Microsoft team member
Sandhya Palle	Microsoft team member
Thejesh Avula	Microsoft team member
Alex Radermacher	Instructor
Henry Brewster	Team member
Jack Morris	Team member
Matthew Brock	Team member
Zachery Miller	Team member
John Nowatzki	NDSU Precision Ag faculty member

TBD	NDSU Precision Ag faculty member

2.4 Project Resources

Resource	Resource Description	Quantity
Capstone Team	Our team of students will be the primary developers of the project.	4
Azure Account	Cloud/PaaS accounts on Microsoft Azure for each of the capstone team members. Do not use your NDSU account.	4
Power BI Desktop	Microsoft Power BI desktop application/account for each of the capstone team members. Do not use your NDSU account.	4
Azure DevOps	An advanced git-based service to be used for version control and file sharing.	4
Computer with the ability to work with MS products	A computer with Visual Studio installed for working with Azure, SQL Server, and SSIS, or any computer that can install software needed to work with these products	≥4
Microsoft Team	Several members of Microsoft will be supporting the project and providing guidance.	6
NDSU Precision Ag department	TBD members from the NDSU Precision Ag department will assist our development	TBD

2.5 Assumptions

#	Assumption
1	All student team members will be available for either online or in-person meetings with Dave Froslie once per week.
2	Student team members will be able to familiarize themselves with MS Azure, Power BI, and .NET Web API
3	Student team members will be able to make or find adequate fake data
4	All necessary paid software licenses will be provided by the Microsoft team and/or NDSU.
5	Access to FarmBeats will be granted by the Microsoft team and/or NDSU Agriculture department.

3.   Project Tracking

3.1   Tracking

Information	Description	Link
Code Storage	Project Code and Commands will be stored on GitHub	Link
Bug Tracking	Bug tracking will also be done with GitHub	Link
Documentation	All non-class related documents will be stored on GitHub (Spec Doc, API/Web App documentation)	Link
Class Documents	Weekly reports, sprint reports, etc. will be stored on Microsoft Teams	Private (no link)
Installation and troubleshooting documentation	The various troubleshooting and other documentation will be stored on Microsoft teams	Private (no link)
Research results and findings	Statistics, test summaries, and findings will be written to Microsoft Teams	Private (no link)

3.2   Communication Plan

Regularly Scheduled Meetings

Meeting Type	Frequency/Schedule	Who Attends
Student Meeting	Thursdays, 12:15pm-End	All NDSU student members
Microsoft Meeting	Tuesday 10:00 am –11:00 am	All NDSU student members and Microsoft members
Sprint Planning	Thursday of the week before the next sprint begins	All NDSU student members
Sprint Review	Thursday of the week after a sprint ends	All NDSU student members

Information To Be Shared Within Our Group

Who?	What Information?	When?	How?
The Project Team	Tasks, status updates, sprint information	Meetings on campus	Team meetings, weekly documents/Project Specification

Information To Be Provided To Other Groups

Who?	What Information?	When?	How?
Mentor, Microsoft team, Precision Ag department	Final Report	At completion of the project	Documentation, research summary, code, and PowerPoint presentation
Mentor, Microsoft team, Precision Ag department	Weekly Report	Weekly	Onsite meetings, Microsoft Teams
Mentor, Microsoft Team, Precision Ag department	Sprint Report	At the end of each sprint	Onsite meetings, Microsoft Teams

Information Needed from Other Groups

Who?	What Information?	When?	How?
NDSU Precision Ag department	Useful Metrics, department requests	Before the development of Power BI analytics	Meeting and/or documents on the subject.

3.3   Deliverables

#	Deliverable
1	Web API
2	Web application
3	Mobile application
4	Desktop application
5	Project specification document
6	Post mortem document
7	Weekly reports
8	Sprint reports

3.4   Project Metrics

Metric	Frequency	Location
Estimated User Story Points	At the start of each sprint	At the beginning of individual sprints
Actual User Story Points Completed	At the end of each sprint	At the end of individual sprints

4. Requirements (User Stories)

4.1 Overall Description

The goal of the project is to create a web app, phone app, and desktop app using a custom Web API. We will embed Power BI analytics into these apps by integrating data from the FarmBeats Azure server. This data will generate useful visuals/metrics that the NDSU Precision Ag department can use during course studies/research.

This project can be broken down into four major steps: (1) We will develop a Web API using the .NET framework and link it to FarmBeats Azure data. (2) We will create a Power BI workspace and feed the formatted JSON API data to it (3) We will create custom visuals in Power BI that connect to the workspace. (4) Embed these visuals into web, desktop, and mobile apps.

4.2 Users and Roles

User	Description
Researcher (customer)	An end user that would be using the app to further research.
Farmer (customer)	An end user that would be using the app in order to help improve their farm.
Capstone Team Member	A member of the capstone team working on the project
Microsoft Team member	A member of the Microsoft team assisting the Capstone Team Members
NDSU Ag department member	A member of the NDSU Ag department assisting the Capstone Team Members

4.3 Use Case Diagrams

Researchers and farmers would be considered our customers

FarmBeats Accelerator Use Case diagram

Henry Brewster | February 17, 2020
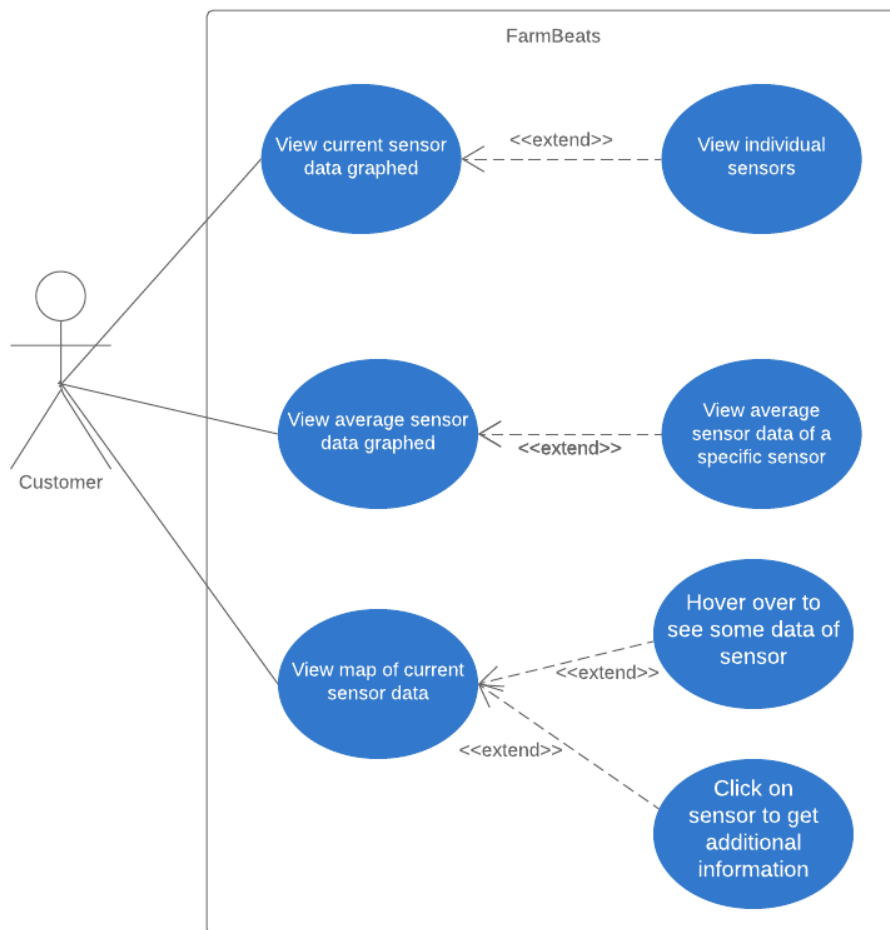
4.4 User Story Baseline

Our point system would be about 1 hour per point.

4.5 User Stories (Requirements)

ID	Feature	Est. Points	Actual Points	Sprint
US-01	Setup .NET API	10	30	2-4
US-02	Setup Azure server	5	5	1
US-03	Setup Power BI account	2	1	1
US-04	Setup Power BI workspace	2	1	1
US-05	Setup Azure DevOps	2	1	1
US-06	Setup Microsoft Teams	2	1	1
US-07	Weekly Reports	20	15	All
US-08	Project Specification document (In progress)	20	20	All
US-9	Sprint report 1	1	1	1
US-10	Populate Azure with data	5	5	2
US-11	Populate Power BI workspace with analytics	10	20	2
US-12	Create a website that integrates Power BI Embedded	30	30	3
US-13	Sprint report 2	5	1	2
US-14	Create a mobile-optimized version of the reports	10	5	4
US-15	Create a desktop app that integrates Power BI Embedded	10	0	3
US-16	Sprint report 3	1	1	3
US-17	Project specification document (final cleanup)	2	2	4
US-18	Final Presentation	10	5	4
US-19	Post mortem documentation	2	10	4
US-20	Sprint report 4	5	1	4

SPRINT 1

Key:

C = Committed to by the team and feature will be implemented

T = Targeted for completion assuming that there is sufficient time

NC = Team is not committing to the requirement, but it is included here for completeness

Total Estimated User Story Points for Sprint 1: **30**

Actual Completed User Story Points for Sprint 1: **30**

Project Management

ID	Added	Description	Status	Story Points	Actual Equivalent Story Points	% Completed
US -02	Onset	As a Capstone Team member, I need to be able to access the Azure server	C	5	5	100
Acceptance Criteria			**Verification**			
2.1	All members get access to the Azure server		Team member can perform Azure jobs through this software			
2.2	Steps of gaining access shall be documented in the final report		Instructor verifies data is in the report			
ID	**Tasks**				**Resource**	
A	Have Microsoft team member add capstone team members to the Azure server				Microsoft team	
B	Try to access Azure Server				Capstone team	
C	Document process				Capstone team	

Project Management

ID	Added	Description	Status	Story Points	Actual Equivalent Story Points	% Completed
US -03	Onset	As a front-end developer, I need to be able to access Power BI	C	2	2	100
Acceptance Criteria			**Verification**			
3.1	All members have access to a Power BI pro account		Team members can perform Power BI jobs through this software			
3.2	Steps of gaining access shall be documented in the final report		Instructor verifies data is in the report			
ID	**Tasks**				**Resource**	
A	Sign up for a Power BI account through its website				Capstone team	
B	Upgrade to a Power BI Pro trial membership				Capstone team	
C	Create a simple Power BI visual				Capstone team	
D	Document process				Capstone team	

Project Management

ID	Added	Description	Status	Story Points	Actual Equivalent Story Points	% Completed
US-04	Onset	As a front-end developer I want to be able to create and post reports to a Power BI workspace	C	2	2	100

Acceptance Criteria		Verification
4.1	All members have a Power BI Pro account	Team members can perform Power BI jobs through this software
4.2	All members can publish reports and charts to a workspace	Add a simple report to your personal workspace
4.3	All members have access to a shared workspace	Add a simple report to the shared workspace
4.4	Steps of gaining access shall be documented in the final report	Instructor verifies data is in the report

ID	Tasks	Resource
A	Set up a Workspace	Capstone team
B	Invite all other members to the shared workspace	Capstone team
C	Publish a simple report to the shared workspace	Capstone team
D	Document process	Capstone team

Project Management

ID	Added	Description	Status	Story Points	Actual Equivalent Story Points	% Completed
US-05	Onset	As a Capstone Team member and as a Microsoft team member I want to be able to access the DevOps server	C	2	2	100

Acceptance Criteria		Verification
5.1	All Capstone team members can access the DevOps server	Team members can perform DevOps jobs on the server
5.2	All Capstone team members can push/pull to and from the server	Make a simple push and pull request to the server and verify it completed.
5.3	Steps of gaining access shall be documented in the final report	Instructor verifies data is in the report

ID	Tasks	Resource
A	Set Up DevOps Server	Microsoft team
B	Give Access to all Microsoft team members	Microsoft team
C	Give Access to all Capstone team members	Microsoft team

D	Perform a simple push/pull request job				Capstone team
E	Document process				Capstone team

Project Management

ID	Added	Description	Status	Story Points	Actual Equivalent Story Points	% Completed
US-06	Onset	As a Capstone team member and a Microsoft team member, I want to be able to access Microsoft Teams	C	2	2	100
Acceptance Criteria			**Verification**			
6.1	All Microsoft Members have access		A Microsoft member sends a chat message			
6.2	All Capstone members have access		A Capstone member sends a chat message			
6.3	All Precision Ag members have access		A Precision Ag member sends a chat message			
6.4	Steps of gaining access shall be documented in the final report		Instructor verifies data is in the report			
ID	**Tasks**			**Resource**		
A	Create a new Microsoft Teams organization			Microsoft Team		
B	Invite all Capstone team members			Microsoft Team		
C	Invite all Microsoft team members			Microsoft Team		
D	Invite all Precision Ag team members			Microsoft Team		
E	Document Process			Capstone Team		

Project Management/document production

ID	Added	Description	Status	Story Points	Actual Equivalent Story Points	% Completed
US-08	Onset	As a Capstone team member, I want to create a feature complete Specification Document that the entire team can reference.	C	20	20	100
Acceptance Criteria			**Verification**			
8.1	Each section of the document is completed as the semester progresses		Instructor verifies each section is done as they are graded			

ID	Tasks	Resource
8.2	Microsoft team members are satisfied with each section	Microsoft team members give their approval to the capstone team
8.3	Steps of creating the Specification doc is documented in the final report	Instructor verifies data is in the report
ID	Tasks	Resource
A	Complete sections 1-3	Capstone Team
B	Complete section 4	Capstone Team
C	Complete sections 5-6	Capstone Team
D	Complete section 7	Capstone Team
E	Document Process	Capstone Team

Project Management

ID	Added	Description	Status	Story Points	Actual Equivalent Story Points	% Completed
US-10	Onset	As a Capstone team member, I need relevant FarmBeats data in order to create the project	C	5	5	100

	Acceptance Criteria	Verification	
10.1	All team members have access to FarmBeats data	Team members can pull/use the data from Azure	
10.2	If no real data is available, all team members have access to mock data	Team members do not have access to the live data, but created and can use a mock data set	
10.3	Steps of gathering/creating the data is documented in the final report	Instructor verifies data is in the report	

ID	Tasks	Resource
A	Get access to real FarmBeats sensor data	NDSU Precision Ag team
B	If real data isn't available, simulate mock data with similar data fields	Capstone Team
C	Document Process	Capstone Team

SPRINT 2

Total Estimated User Story Points for Sprint 2: 45
Actual Completed User Story Points for Sprint 2: 60, Spread out over Sprints 2-4

Project Management

ID	Added	Description	Status	Story	Actual	%

			Points	Equivalent Story Points	Completed
US-11	Onset	As a Front-end developer, I want to create several Power BI reports to show data in a meaningful way	C	10	20	100

Acceptance Criteria		Verification
11.1	We have a live map, specific sensor page, and any other analytics we might need	The live maps, sensors, and any needed analytics are completed
11.2	The NDSU Precision Ag team approves of our mock-ups	The mock ups have been approved by the Ag Team
11.3	The NDSU Precision Ag team approves our final analytic designs	The final designs have been approved by the Ag Team
11.4	Steps of creating these Power BI reports are documented in the final report	Instructor verifies data is in the report

ID	Tasks	Resource
A	Meet with the NDSU Precision Ag team to discuss what visuals and reports they would like implemented	Capstone team/NDSU Precision Ag team
B	Create mockups for the sensor map, sensor data and whatever analytics we discussed	Jack & Matt
C	Create a final version of the sensor map	Jack & Matt
D	Create a final page for specific sensor infographics.	Jack & Matt
E	Document the process	Jack & Matt

Project Management

ID	Added	Description	Status	Story Points	Actual Equivalent Story Points	% Completed
US-01	Onset	As a back-end developer, I want to create a web API that formats raw FarmBeats data in a way that Power BI can understand	C	10	40	95

Acceptance Criteria		Verification
1.1	Be able to send data to Power BI	Power BI accepts and can use data from the web API
1.2	Be able to take in data and format it	The web API successfully takes in data from Azure and properly formats it
1.3	Steps of creating the web API are documented in the final report	Instructor verifies data is in the report

ID	Tasks	Resource
A	Create a default Web API	Henry
B	Format the data in a way that is helpful	Henry
C	Take in information from an Azure server	Henry
D	Document the process	Henry

SPRINT 3

Total Estimated User Story Points for Sprint 3: 20
Actual Completed User Story Points for Sprint 3: 30, plus more from API (Sprint 2)

Functional Requirement

ID	Added	Description	Status	Story Points	Actual Equivalent Story Points	% Completed
US-12	Onset	As a Researcher (customer), I want to use a functional web app that can visualize FarmBeats sensor data.	C	30	30	100

Acceptance Criteria		Verification	
12.1	A web app is hosted with all the analytics needed	The website is running and accessible via an address	
12.2	Power BI is embedded in the application	Power BI is able to access the data from the web API and properly creates visualizations	
12.3	The web API is fully integrated	The website is able to receive proper data from the web API through API calls	
12.4	Steps of implementing the web app is documented in the final report	Instructor verifies data is in the report	

ID	Tasks	Resource
A	Create a default web app	Capstone Team
B	Embed Power BI into the web app	Jack & Matt
C	Integrate the web API	Henry
D	Test all possible functionality within the web app	Capstone Team
E	Document the process	Capstone team

SPRINT 4

Total Estimated User Story Points for Sprint 4: 22
Actual Completed User Story Points for Sprint 4: 20, plus more from API (Sprint 2)

Functional Requirement

ID	Added	Description	Status	Story Points	Actual Equivalent Story Points	% Completed
US-14	Onset	As a farmer (customer), I want to be able to interact with the Power BI visuals on my phone	T	10	5	100
Acceptance Criteria			**Verification**			
14.1	There is a working mobile website		The mobile-friendly website is reviewed by the Microsoft/Precision Ag team			
14.2	The Power BI visuals are properly formatted/scaled when viewed on mobile.		Power BI reports are correctly shown when accessed on a mobile device.			
14.3	There is no missing functionality from desktop to mobile conversion		All functionality is working when tested			
14.4	Steps of implementing a mobile version of the web app is documented in the final report		Instructor verifies data is in the report			
ID	**Tasks**				**Resource**	
A	Convert the web app to work on mobile				Jack & Matt	
B	Make sure Power BI visuals are properly formatted when viewed on mobile				Jack & Matt	
C	Make sure functionality is present from the desktop version of the web app				Jack & Matt	
D	Document the process				Jack & Matt	

Project Management

ID	Added	Description	Status	Story Points	Actual Equivalent Story Points	% Completed
US-18	Onset	As a Capstone Team member, I am to present our feature-complete capstone project to the class and our sponsor, Microsoft.	C	10	5	100
Acceptance Criteria			**Verification**			
18.1	A presentation is created		The group members finalize the presentation details and save the presentation			

ID		Tasks	Resource
18.2		We present our presentation to the instructors and sponsors	Instructor grades our presentation
18.3		We deliver any final work to Microsoft and the instructors	Both parties are satisfied with the deliverables
18.4		Steps of preparing for and presenting the final presentation are documented in the final report	Instructor verifies data is in the report

ID	Tasks	Resource
A	The Capstone team members need to create a power point	Capstone team
B	The Capstone team needs to practice the presentation	Capstone team
C	The Capstone team must present their final presentation to the class and sponsors	Capstone team
D	Document the process	Capstone team

Project Management/Document Production

ID	Added	Description	Status	Story Points	Actual Equivalent Story Points	% Completed
US-19	Onset	As a class instructor, I want to know how the project went.	C	2	10	100

Acceptance Criteria		Verification	
18.1	A final postmortem report is completed by the capstone team	Instructor verifies the postmortem document has been turned in and graded	

ID	Tasks	Resource
A	Make a postmortem document	Capstone team, Blackboard templates
B	Combine all documentation gathered throughout the entire semester and summarize it.	Capstone team
C	Share the final report with the Microsoft team	Capstone team
D	Turn in the final report on Blackboard	Capstone team

4.6   Constraints and Limitations

Constraint	ID
Our NDSU Accounts don't have the permissions needed in order to access some features	US-03, US-04, US-11

5. Design

5.1 Introduction

As mentioned previously, the goal of this project is to create a tool which helps to visualize farming data. The Precision Ag Department aims to use this tool in their Ag program and get students comfortable with using it. As per the design of the project, the structure is simple. NDSU has an Azure subscription which contains information about the FarmBeats project, along with the data captured by the FarmBeats sensors. Firstly, we are creating a web API to pull and properly format data from the Azure subscription. Then, the API will send the data to a webpage embedded with Power BI.

Once Power BI is given the data, a detailed report will be created that contains a Bing Map displaying all of the farming sensors. The report will display the averages for the entire data set, but you can also focus on a specific sensor to see more details about farm conditions near that sensor. This structure will allow for users to analyze the data and discover trends within the data which could be used to help run a farm more efficiently.

5.2 Scope

The goal of the project is to create usable visual reports for the Precision Ag Department at NDSU. While this could be a huge undertaking, our scope has been narrowed for a variety of reasons. NDSU's Azure subscription is running off of credits from a grant. Due to this, we cannot make any changes to the structure of the subscription, as it may impact costs for NDSU. On top of this, our project will also serve as a template for a similar project by Microsoft in the future. Due to this, our scope has been narrowed down to the core features that our project will need to function correctly.

The project will be used by the Precision Ag department at NDSU in classrooms/labs in an effort to familiarize students with the technology. Due to our limited amount of time and resources, our design needed to be made efficiently. Our visuals from Power BI will provide basic, yet useful, information to the department. Our main focus will be put towards creating a webpage that makes use of embedded Power BI, as it is a much easier process to access reports via webpage than to manually load them into Power BI Desktop.

5.3 High-Level Component Design

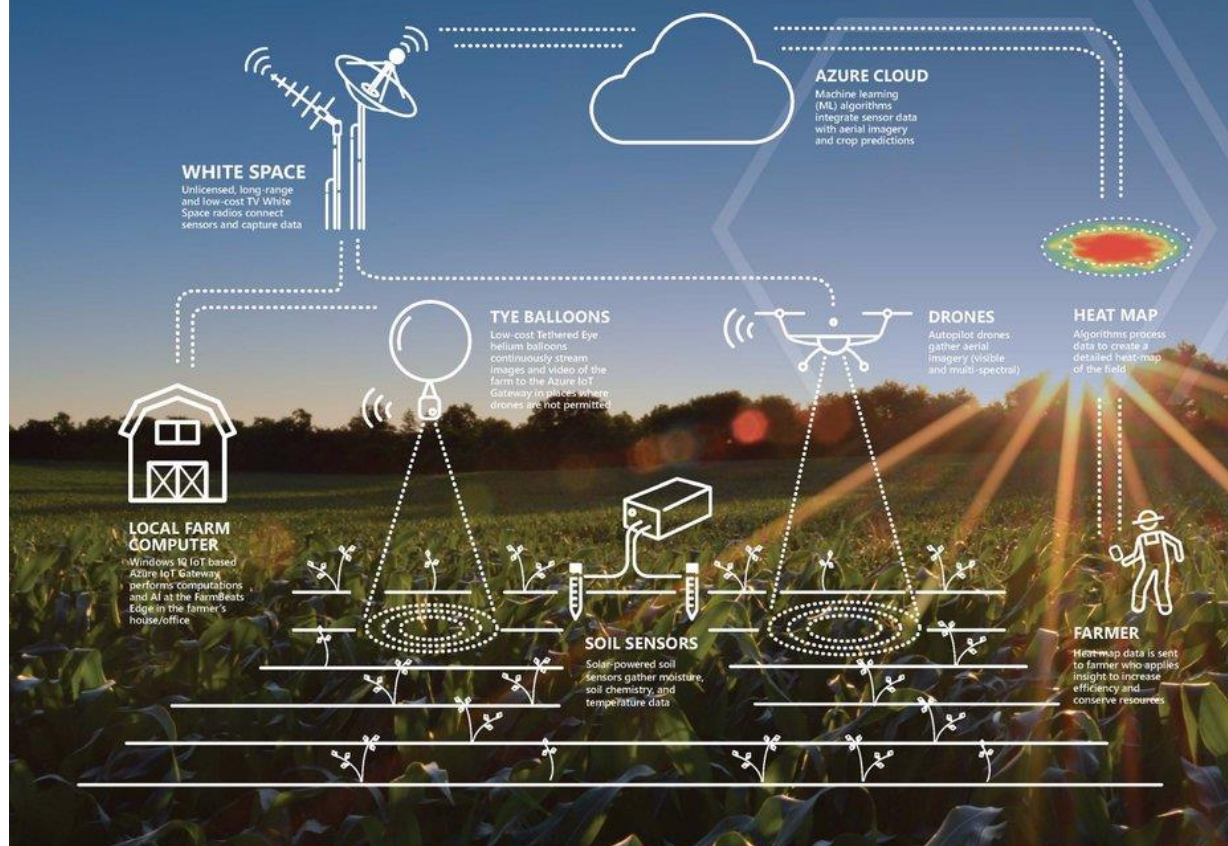| ID	Component	Related Requirements	Description
01	FarmBeats Sensor Kit		These sensors gather a wide range of data, and then upload the data to Precision Ag's Azure subscription storage account.

02	Azure Active Directory	US - 02	This component is where all of the data related to FarmBeats is stored/accessed.
03	Azure Dev-Ops	US - 05	This component contains repositories where all of the NDSU student team's code lives.
04	Personal Computer	US – 02, US - 05	This component is used to access the Microsoft Azure Subscription, Azure DevOps, and Power BI for one team member.
05	Personal Computer	US – 02, US - 05	This component is used to access the Microsoft Azure Subscription, Azure DevOps, and Power BI for one team member.
06	Personal Computer	US – 02, US - 05	This component is used to access the Microsoft Azure Subscription, Azure DevOps, and Power BI for one team member.
07	Personal Computer	US – 02, US - 05	This component is used to access the Microsoft Azure Subscription, Azure DevOps, and Power BI for one team member.
08	Power BI Workspace	US-03 US-04 US-11	This component is used to host all Power BI visuals and datasets.
09	API	US-01, US-10	This component will gather/parse FarmBeats data from the Azure storage account.

5.3.1 Official FarmBeats Diagrams:

// AI for Earth

FarmBeats

FarmBeats provides farmers with access to the Microsoft Cloud and AI technologies, enabling data-driven decisions to help improve agricultural yield, lower overall costs, and reduce the environmental impact of agricultural production.

AZURE CLOUD
Machine learning (ML) algorithms integrate sensor data with aerial imagery and crop predictions

WHITE SPACE
Unlicensed, long-range and low-cost TV White Space radios connect sensors and capture data

TYE BALLOONS
Low-cost Tethered Eye helium balloons continuously stream images and video of the farm to the Azure IoT Gateway in places where drones are not permitted

DRONES
Autopilot drones gather aerial imagery (visible and multi-spectral)

HEAT MAP
Algorithms process data to create a detailed heat-map of the field

LOCAL FARM COMPUTER
Windows 10 IoT based Azure IoT Gateway performs computations and AI at the FarmBeats Edge in the farmer's house/office

SOIL SENSORS
Solar-powered soil sensors gather moisture, soil chemistry, and temperature data

FARMER
Heat map data is sent to farmer who applies insight to increase efficiency and conserve resources

Challenge

Several studies have demonstrated the need to significantly increase the world's food production by 2050. However, there is a limited amount of additional arable land, and water levels have also been receding. Our goal is to enable data-driven farming. We believe that data, coupled with the farmer's knowledge and intuition about his or her farm, can help increase farm productivity, and also help reduce costs. However, getting data from the farm is extremely difficult since there is often no power in the field, or Internet in the farms. As part of the FarmBeats project, we are building several unique solutions to solve these problems using low-cost sensors, drones, and machine learning algorithms.

Solution

FarmBeats uses TV White Spaces (TVWS) radios to wirelessly connect sensors and capture data; and machine learning (ML) algorithms to integrate sensor data with aerial imagery and other relevant data (such as weather, crop predictions, and best practices) to deliver actionable insights to farmers, all at a fraction of the cost of existing solutions. Our collaborators—the government of India, the Gates Foundation, and leading agricultural companies, such as BASF, Bayer, Land O'Lakes, and Mahindra—are crucial to this effort, and support our longstanding commitment to sustainability. This is a digital transformation of agriculture, at both small and large scales, that's critical to meeting 21st century food-supply challenges.

AGRICULTURE   WATER   BIODIVERSITY   CLIMATE CHANGE

Microsoft

For the purposes of this Capstone project, we are focusing specifically on the Soil Sensors outlined in these official diagrams.

5.3.2 Sensor-Azure Component connection

FarmBeats sensors are strategically placed throughout a research farm, then sensor data is relayed back to the Azure Storage account.
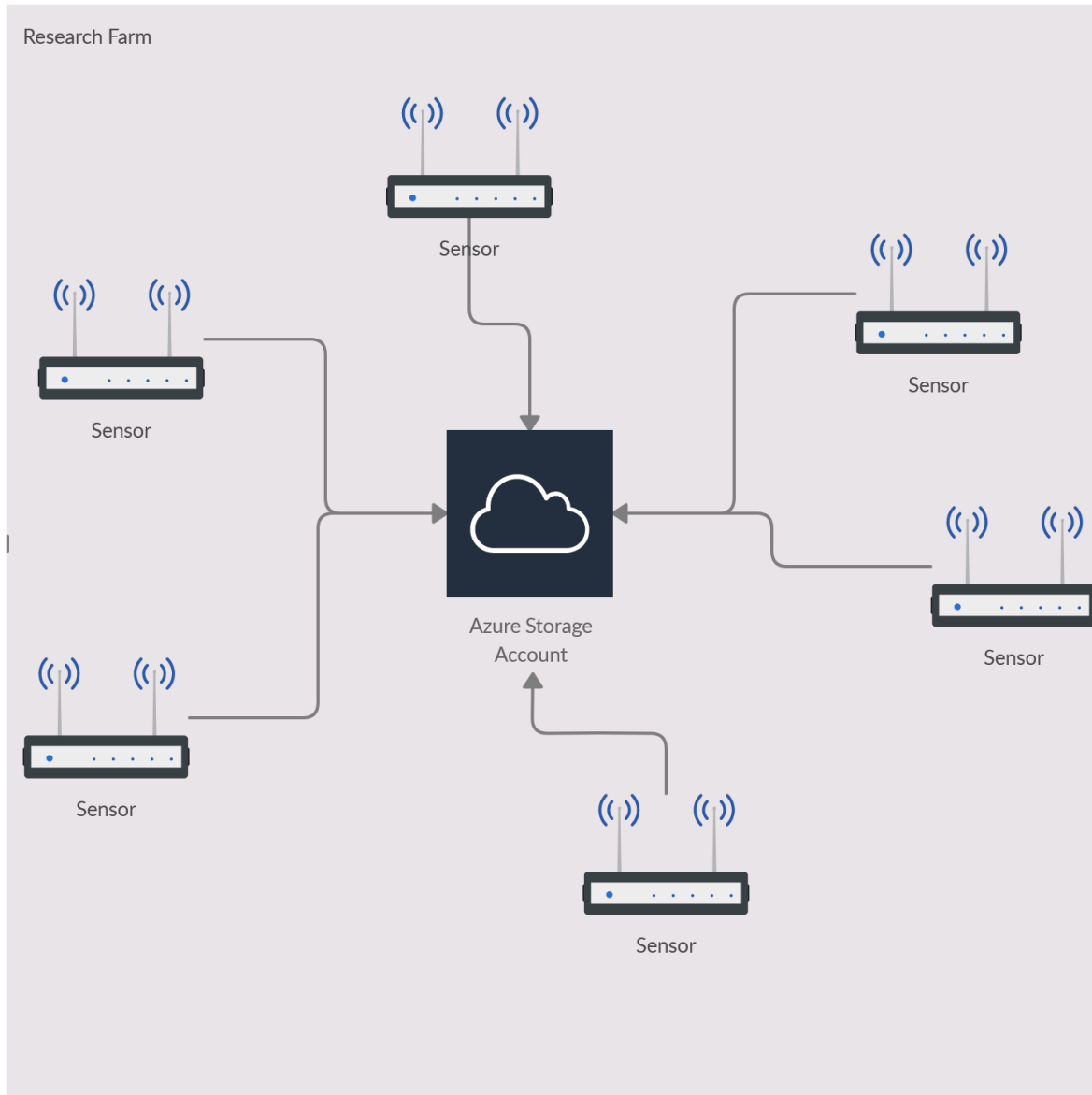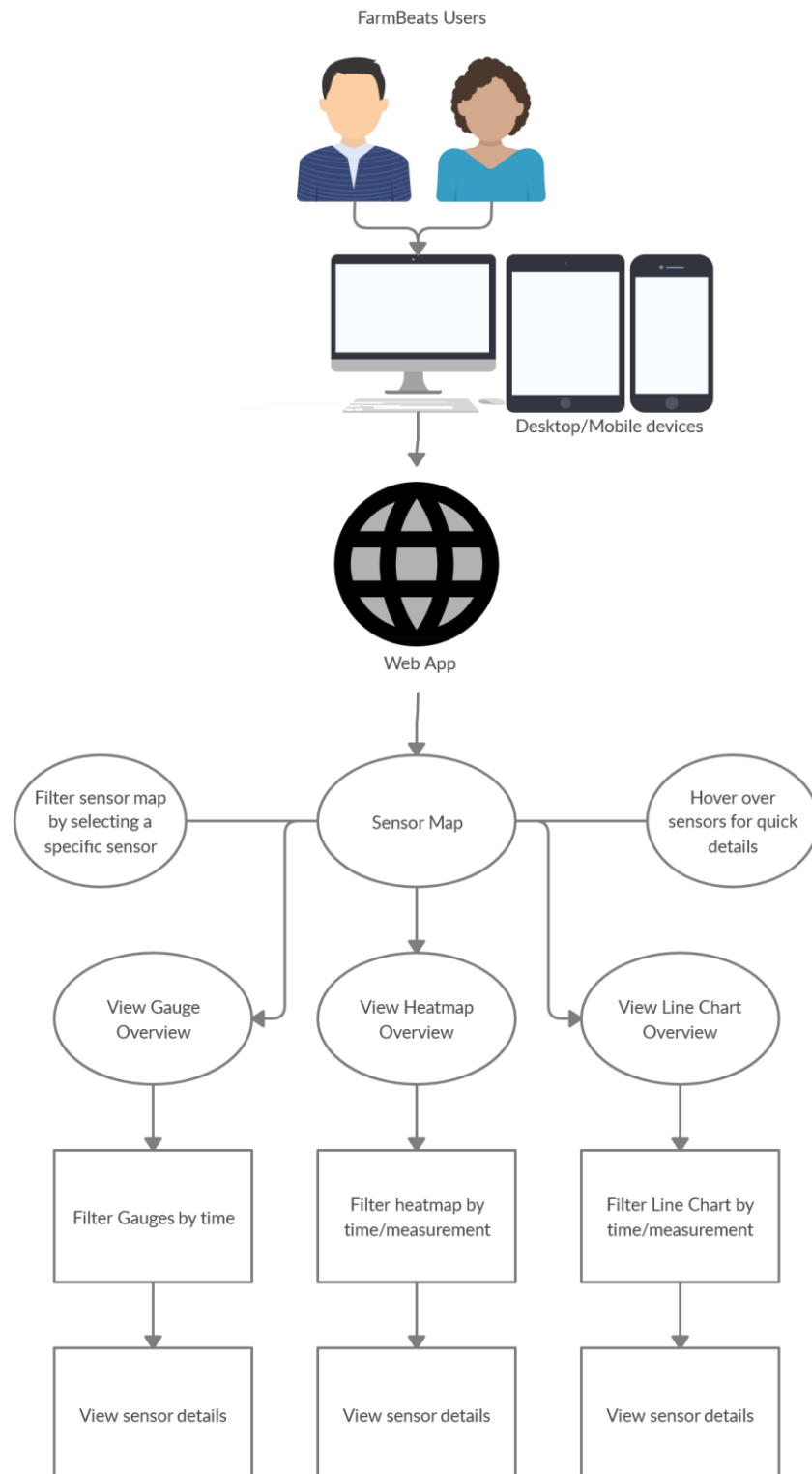

5.4 Class Diagram

(Classes and methods are automatically handled by Power BI)

5.5 Web App Flowchart

Diagram 5.5 shows how users can interact with our web app. Reports will be viewable on both

desktop and mobile devices. The three main pillars of data display will be Gauge View, Heatmap View, and Line Chart View. Each view will be filterable by time and sensor measurement.

5.6   Sequence Diagram

Diagram 5.6 shows how the Power BI Embedded reports will be loaded into our web app. All embedded reports must be made in our Power BI workspace before they can be embedded. These reports will use data from a json string file generated by our API. The API will check for data within NDSU Precision Ag's Azure Data Storage account, where all FarmBeats sensor data is being uploaded.
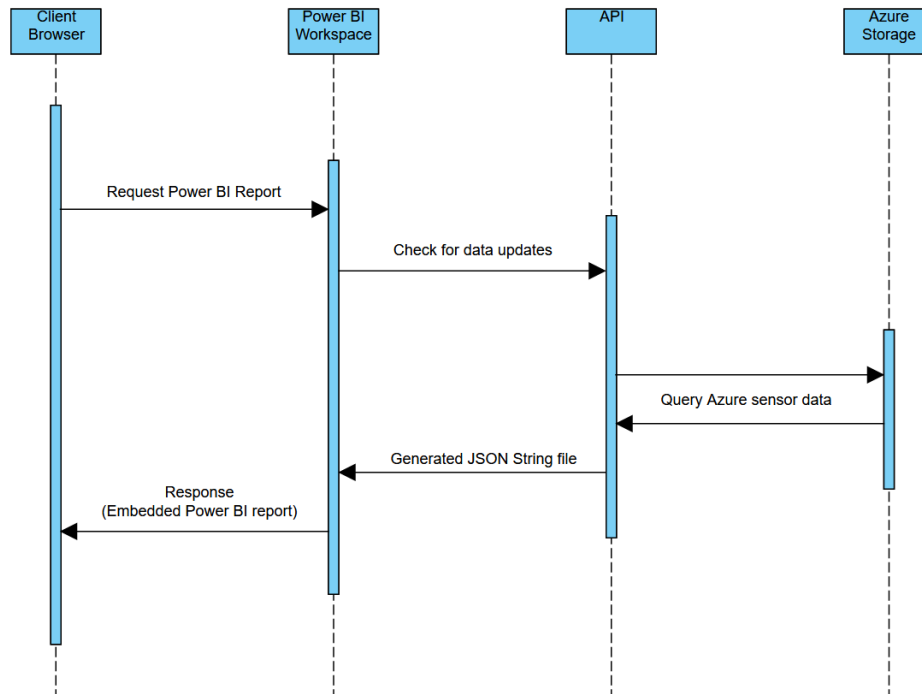
5.7   Alternative Designs and Design Rationale

One alternative design for the project would be to use SQL tables in Azure instead of using Azure Storage Tables. This would allow us to have the data properly formatted in the cloud, allowing us to bypass having to create a web API. However, creating a new SQL table would add to the cost for NDSU, who has limited credits for Azure, so this design was not feasible for this project.

The rationale for our project's design came from multiple limitations on our project. Since many paths for the project would come at a cost to NDSU, we had to try and use the most cost-effective design possible. The FarmBeats sensor -> Azure Storage Tables -> Web API -> Power BI design will meet all of the requirements for the project, as well as being cost-effective for NDSU.

5.8   Data Architecture

(Data architecture is handled by FarmBeats and Azure. For the purpose of our capstone, we are accessing data that is already present, and data architecture diagrams aren't needed)

6.   User Interface

6.1   UI Description

Users will be interacting with a web app that will allow the user to view different Power BI reports as well as update the location of the sensor. These reports are embedded below the menu bar, and they retain all of their features. Below, we will provide descriptions of the different report tabs we designed, along with a quick tutorial on how users may interact with them. On each tab, you may notice a filter column along the right side of each report. Users do not need to interact with this column, as it is purely informative. Filters are applied automatically by drill through functions.

6.2   UI - Final Design

6.2.1 Sensor Map View
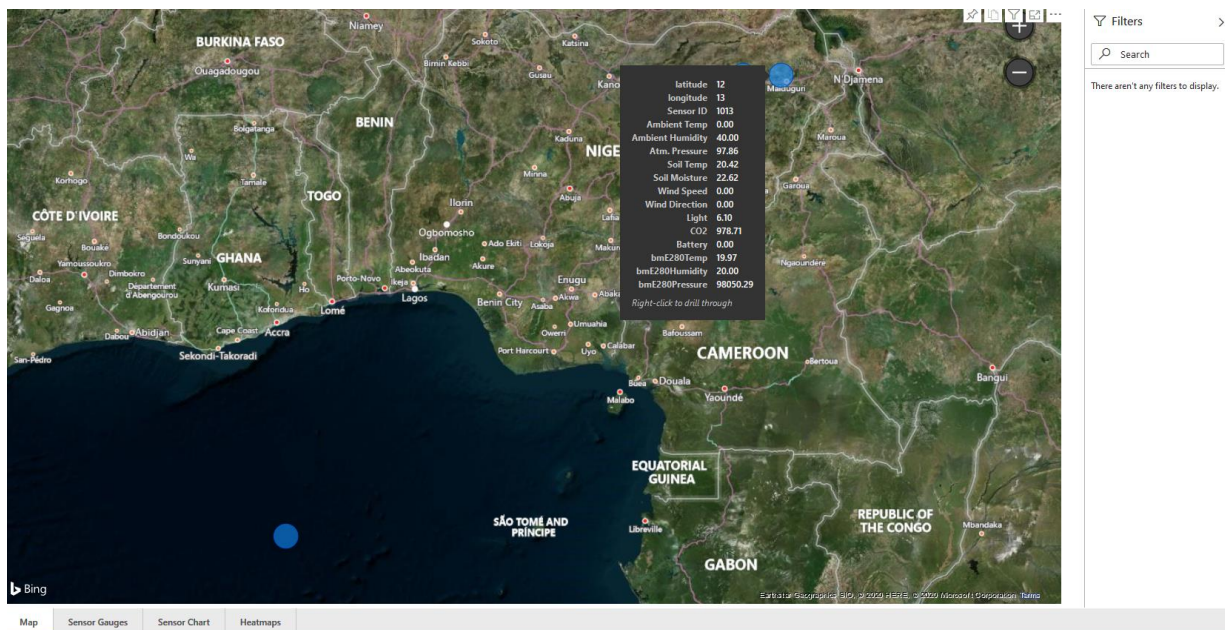
The Sensor Map View is the default tab of the report, and acts as the sensor directory. Users may quickly hover over any sensor to see a snapshot of its current measurements, or they may click on an individual sensor and drill through to any of the other tabs: Gauge View, Line Chart View, and Heatmap View. To drill through on a sensor, users can right-click (or long press if on a mobile device) and select the drill through option. Additionally, this map can be manipulated by the user by position and zoom level.
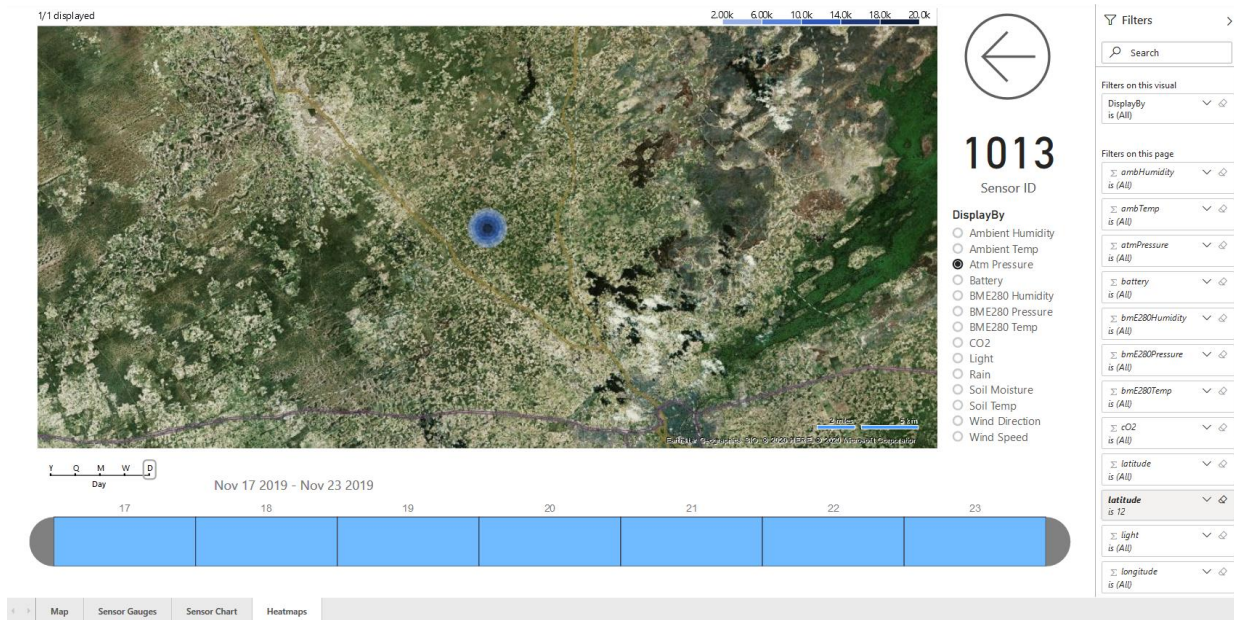
6.2.2 Gauge View
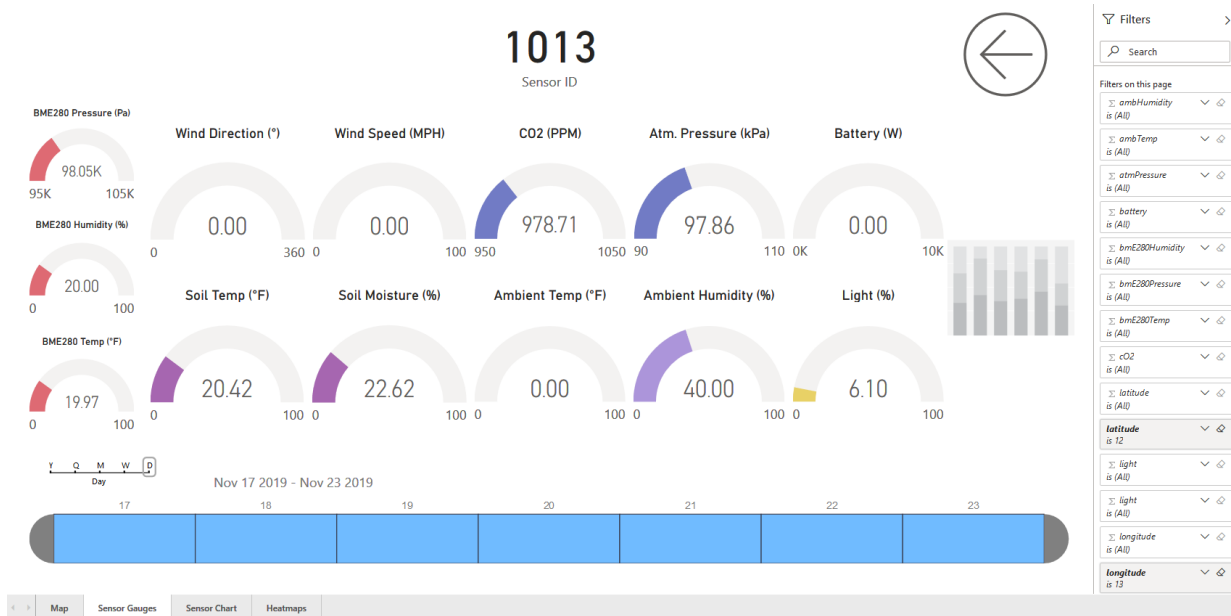
Gauge View is a drill through tab that displays data from any sensor selected on the map view tab. Data includes all types of measurements that the FarmBeats sensors are currently set up to monitor/collect. These gauges will show the <u>average</u> of each measurement over the time period selected. To select a time period, users can click (or touch if on a mobile device) and slide along the blue ribbon to select their desired date range. This ribbon can be filtered by year, quarter, month, week, or day. **This view will display no information unless it is accessed through a drill through command, so users MUST select a sensor on the Map View tab, then drill though to this page to see it populated with data.** Once it is populated with data, that data will persist until the page is reloaded or a new drill through request is made for a different sensor. There is also a back button in the top right corner that will return the user to the most-recently visited tab.

6.2.3 Line Chart View

Line Chart View is a drill through tab that displays data from any sensor selected on the map view tab. Data includes all types of measurements that the FarmBeats sensors are currently set up to monitor/collect. These gauges will show the <u>exact values</u> of each measurement over the time period selected. To select a time period, users can click (or touch if on a mobile device) and slide along the blue ribbon to select their desired date range. This ribbon can be filtered by year, quarter, month, week, or day. **This view will display no information unless it is accessed through a drill through command, so users MUST select a sensor on the Map View tab, then drill though to this page to see it populated with data.** Once it is populated with data, that data will persist until the web app is reloaded or a new drill through request is made for a different sensor. There is also a back button in the top right corner that will return the user to the most-recently visited tab.

6.2.4 Heatmap View

Heatmap View is a drill through tab that displays data from any sensor selected on the map view tab. Data includes all types of measurements that the FarmBeats sensors are currently set up to monitor/collect. These gauges will show the <u>values of each measurement in a heatmap color format</u> over the time period selected. To select a time period, users can click (or touch if on a mobile device) and slide along the blue ribbon to select their desired date range. This ribbon can be filtered by year, quarter, month, week, or day. **This view will display no information unless it is accessed through a drill through command, so users MUST select a sensor on the Map View tab, then drill though to this page to see it populated with data.** Once it is populated with data, that data will persist until the web app is reloaded or a new drill through request is made for a different sensor. There is a back button in the top right corner that will return the user to the most-recently visited tab. Additionally, this map can be manipulated by the user by position and zoom level.

Note: The time range ribbon is persistent on each drill through tab. For example, if a user selects a certain time range on the Gauge View tab, but then drills through to the Line Chart View tab, that same time range will be selected on <u>both</u> tabs.

6.2.5 Update Sensor Location

Within the Web App (not Power BI report) menu bar, there is an "Update Location" tab. This tab is only to be used when a user needs to modify an existing sensor's coordinate location, or to add a new sensor's initial coordinate location. **The sensor must already be running and outputting data to Azure storage before this function can be used.** There are three text fields and a submit button. Users will need to fill in each text field accordingly (latitude, longitude, and sensor ID). Once the user verifies that each field is correct, they will press the submit button. If done correctly, the new or modified sensor will show up on the Map View tab after the next scheduled Power BI data refresh time (currently set to every 24 hours). If the entered Sensor ID does not already exist in the database, an error notification will appear, and the user must verify that the ID is correct.

7.   Project Closure

7.1   Goals / Vision

Originally, we planned to have a desktop/mobile optimize web app which embedded Power BI reports, as well as additional research into AI data predictions. We were on track to hit this goal until sprint 3, when FarmBeats got switched from research to public preview, and our data endpoints got switched from Azure storage tables to the FarmBeats web API. This shifted our goals to be getting a working web app with embedded reports, as well as very good documentation of our development process.

7.2   Delivered Solution

The deliverable for the project includes a web app that displays embedded Power BI reports, and a web API to query data and return it as a json string. There is also an additional tab within the web app that updates a sensor's coordinate location. The way they work together is the web API would query the FarmBeats web API and transform the data in a way that Power BI can read and work with. Then we created analytics with Power BI to display the data in meaningful ways. Finally we embedded those reports into a simple web app that allows the researchers to view the data.

7.3   Remaining Work

We still are having some issues on the web API side of things, as the authorization is taking longer than expected. Once the authorization is done, we have to do some final checks to make sure everything works well together. We also have to finish up some documentation so that when others work with our accelerator, or FarmBeats in general, they have a better understanding of what they are doing.

8. Definitions and Acronyms

Term	Definition
Web API	Application program interface for either a web server or web browser
Azure	https://azure.microsoft.com/en-us/
Power BI	https://powerbi.microsoft.com/en-us/
FarmBeats	https://www.microsoft.com/en-us/research/project/farmbeats-iot-agriculture/
Visual Studio	https://visualstudio.microsoft.com/
GitHub	https://github.com/
NDSU	North Dakota State University https://www.ndsu.edu/cs/