QATra Irrigation System
Functional Modeling

Texas A&M University at Qatar
ECEN 403: Electrical Design Lab I

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“An aggie doesn’t lie, cheat or steal, or tolerate those who do.”

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1. Introduction

The objective of this assignment is to present an upper level functional model and a detailed block diagram of QATra irrigation system. In this block diagram we will include the specific components of our system: the mobile application, the watering system and the control system and explain how they are all connected. Moreover, we will explicitly mention the information we will be needing to implement this system as well as the supporting software or hardware that will be used in the system. This will allow us to fully understand how the system is connected and functioning, as well as being able to find out, in an early stage of the design process, some concerns or constraints that might affect the model of the system. Understanding the system as a single input-output entity and as a model broken down into sub functions can help the team members visualize the system and have a clear, structured representation of it and its purpose.

2. Upper Level Functional Modeling

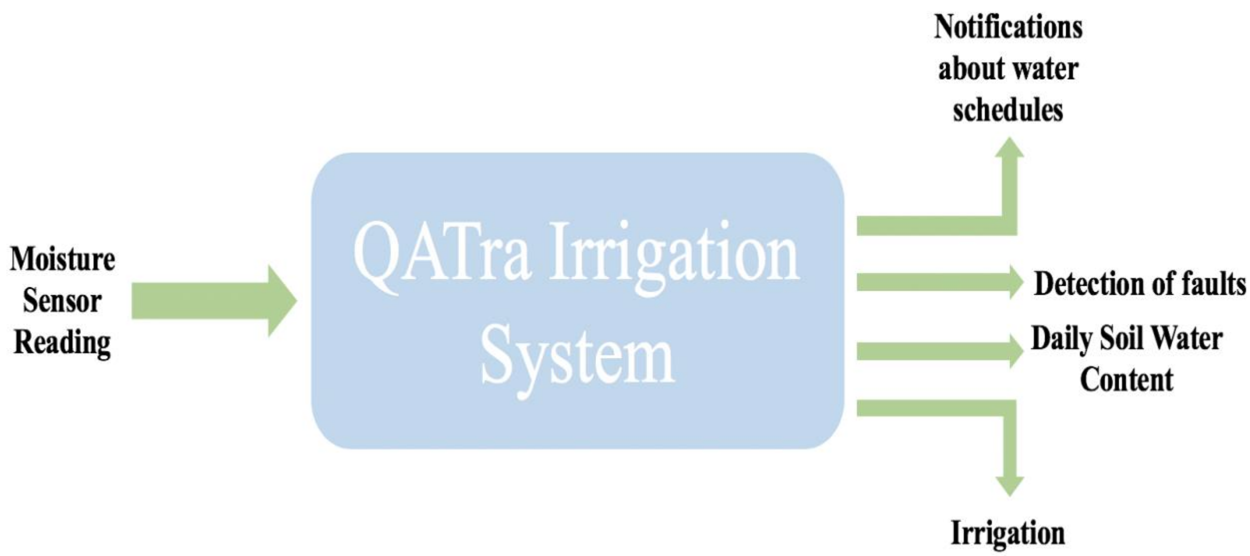

Figure 2.1: Upper Level Functional Modeling

3. Detailed Functional Modeling

3.1 Detailed Block Diagram Representation of Our System

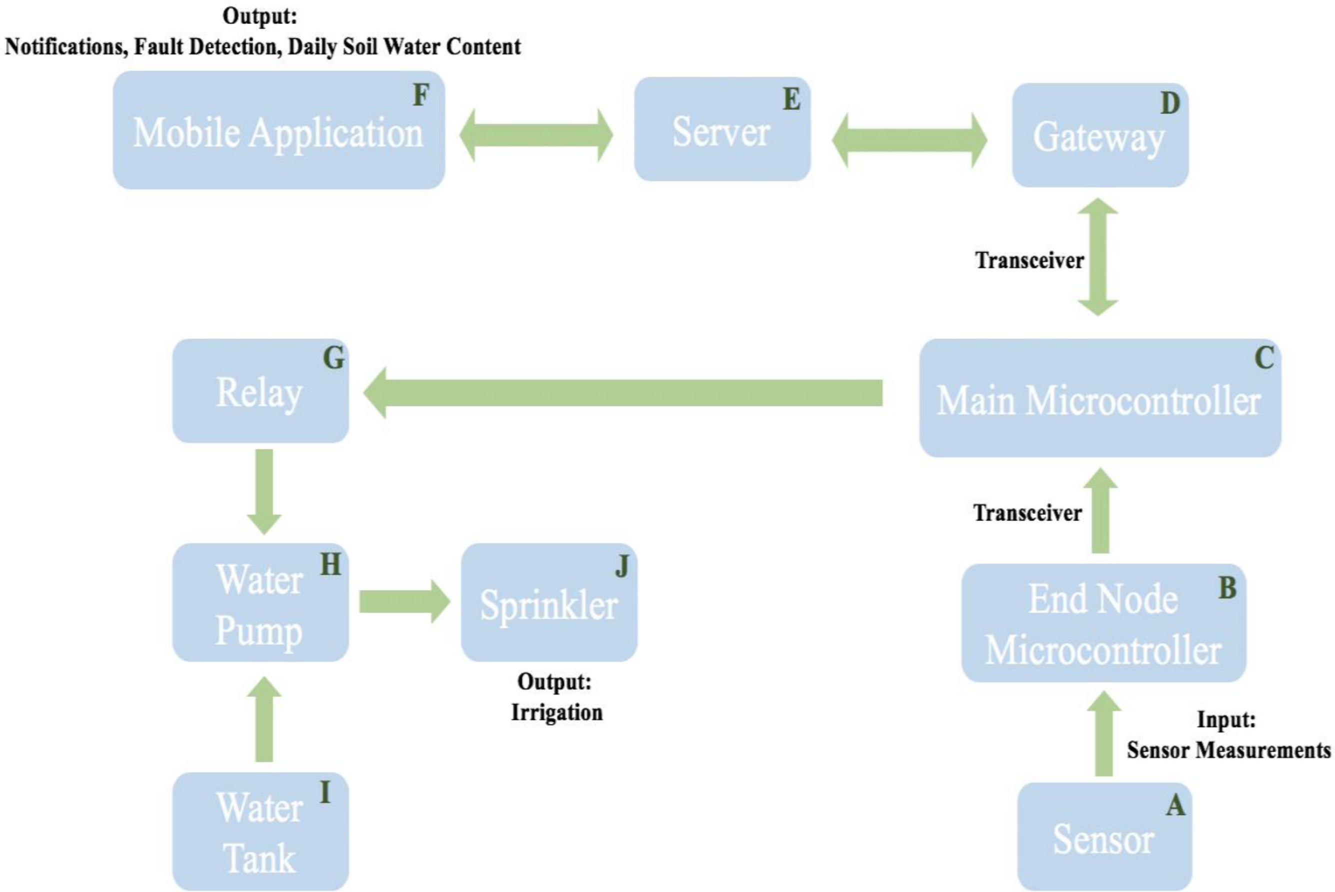

Figure 3.1: Detailed Block Diagram of Our System

3.2 Explanation of Block Diagram Functions

Sensor (A) - End Node Microcontroller (B) Connection:
Each soil moisture sensor is paired with a small end node microcontroller. The sensor has a wired connection with the microcontroller. Each microcontroller-sensor pair (we have a total of 4 pairs in our prototype) is placed near the root zone of the plant. Each sensor will be responsible for measuring the soil moisture of a specific portion of the agricultural land (where it will have certain sprinklers responsible for it). This is done to have control over individual sections of the whole agricultural land. The job of the end node microcontroller is to take the soil moisture readings that are measured from the sensor to the main microcontroller.

End Node Microcontroller (B) - Main Microcontroller (C) Connection:
The end node microcontroller transmits the data gathered from sensor to the main microcontroller. The data is transmitted using a transceiver (wireless communication) which follows the zigbee protocol. The main microntroller's job is to compare the soil moisture level with a specific water threshold levels. If the moisture level is below the minimum water threshold level then the main microcontroller will run the watering system (connected to the sprinkler) to irrigate the plants. However, if the water level was above the maximum water threshold level then the main microcontroller will not allow the irrigation of plants. The details of the communication between the main microcontroller and the water system will be further discussed below.

Main Microcontroller (C) - Gateway (D) Connection:
The main microcontroller communicates with the gateway by sending data of the soil moisture sensor using a transceiver. The purpose of the gateway is to continuously update the mobile application with the data collected. The gateway can receive instruction from the application (user) to interfere with the system in which the gateway will communicate back to the main microcontroller. This will be further discussed below.

Gateway (D) - Server (E) Connection:
The gateway communicates with the mobile application through a server. The server is a software platform or hardware device that organizes the networking between the two devices. The server responds to or receives requests from the client (user application).

Server (E) - Mobile Application (F) Connection:
The server sends data and receives instructions from the mobile application continuously. This includes: soil moisture readings or notification related to fault detection (where it informs the user about a potential problem). The mobile application will be the client of the server. Also, the user can control the irrigation system through the mobile application, which will communicate back to the server (server-to-gateway and then gateway-to-main microcontroller).

Main Microcontroller (C) - Relay (G) Connection:
The main microcontroller will have the moisture level readings and if minimum threshold is reached the main microcontroller will turn the relay switch on. The relay is an electrical on/off switch used to control the water pump. Once the relay is turned on according to the threshold value from the microcontroller, the pump will supply water to the system. The input of the relay switch can come from end nodes (automation) or from the user through the mobile application (control). This will result in controlling the flow of water.

Relay (G) - Water Pump (H) Connection:
The relay will switch the water pump on or off depending on the sensor reading or user's command using the mobile application. In our prototype, there will be four relays and four water pumps. This was done because of the feature that allows each water sprinkler to be controlled individually.

Water tank (I) - Water Pump (H) - Water Sprinkler (J) Connection:
The water pump will be connected through a pipe network to the water tank on one side, and the water sprinkler on the other side. The water pump will receive the signal from the relay when it

needs to be on or off. If it has to be on, it will pump water from the tank to the sprinkler. As mentioned above, there will be four water pumps, each of them will be connected to a sprinkler.

Fault detection implemented in block diagram:
The faults of the system come from different parts of the system. Since the connection of the irrigation system is complex, fault can occur in more than one place and for several reasons so there is no exact or clear part of the system to pinpoint the fault. Therefore, it was discovered that it might be difficult to specify the fault component from certain parameters such as sensor readings over a period of time. Since the time to implement this project is a constraint, it was decided to notify the user of a potential fault in the system. This is important since it will keep the user up to date with the system by giving a warning that there might be a potential problem in the system and advise the user to check the system.

3.3 Information Needed for Our Design

Our design depends on many different aspects of agriculture. Thus, information related to planting and agriculture is required to build and program our prototype. According to Qatar's weather conditions, specific plants with specific soil type are more suitable to be planted here in Qatar. Moreover, using a book titled 'Water, Agriculture, and Environment in Arid Lands' , that was borrowed from an agricultural specialist (Osman Abdalla), we will be able to find information on the appropriate type of plants and soil. To be able to complete the implementation of our smart irrigation system, moisture level threshold should be found for each of the chosen type of plant. When interviewing Osman Abdalla (Agriculture specialist), he suggested that we can find this information from The Food and Agriculture Organization (FAO) website. Also, regarding the time duration between each sensor reading to check for the moisture levels, this can be identified from The Food and Agriculture Organization (FAO) website as Osaman Abdalla recommended.

3.3.1 Hardware and Software Components that Will be Used in Our Design:

Different hardware and software components will be used in our system. These components include: Arduino microcontrollers, soil moisture sensors, Raspberry Pi, pipes, water pump, water tank, sprinklers and relay. The mobile application will be built using XCode software which uses Swift programming language. The programming of the soil moisture sensor will be done using the Arduino Software (IDE) which operates in C programming language. The Raspberry Pi that acts as a gateway between the mobile application and the system will be programmed using Python language. Therefore, knowledge and background of these different programming languages should be grasped prior to implementation of prototype.

4. Analysis and Evaluation of Assignment

Dividing the functional modeling into an upper level and a detailed functional model allowed us to look at the system's input and output as a whole and from that develop the process of each part. It also gave us an insight into the parameters needed for the irrigation system and the condition it should follow (moisture level given minimum and maximum thresholds). From that, the decision will be made on whether to activate the sprinklers or not.

The functional modeling also allowed us to look into the fault detection technique. After looking into this matter, we concluded that fault detection is a large field and it will be difficult to identify the exact faulty equipment or component. Therefore, the user will be notified if there might be a potential fault in the system. This resulted in slight changes to our initial design. Moreover, the sequence and order of data transfer was analyzed in detail which will help us in the programming stage and get a clearer understanding of the connection for the hardware and software.