Team Name: Honey Badgers

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Target accomplishment by the report date:

Basic functionality of the prototype is to be established, including:

- Radio communication between controller and command station
- Sensor readings collected
- Water valve will open and close by command

Actual accomplishment by the report date:

- We now have the Arduino and Raspberry Pi sender and receiver code combined into a single sketch/script on each device such that the Arduino sketch can send data to the Raspberry Pi, and vice versa. Our initial test code sends a list of numbers from the Arduino, the Raspberry Pi delimits and interprets the numbers, and responds to the Arduino with the sum of the original list. This test code mimics the basic interaction of our system in an easily testable manner.
- We now have code in python that will run on the Raspberry Pi that can write information to an external file, and a webserver that will retrieve data from that file and serve it to a user interface where it can be displayed in a browser on another computer. The browser, in turn, renders a form that collects user input that the server writes to a second file that can be read by the python script in communication with the Arduino.
- The physical prototype including weather proof enclosures for the sensors, controller, and valve manifold are mostly complete.
- The final algorithm for the irrigation system automatic scheduling has been established.
- A draft of the radio data transmission message structure is underway.

Analysis of the progress:

We are close to our target accomplishment, but integration is still ongoing. There ended up being a delay from the previously unrealized need of a real time clock, which arrived on Wednesday. At this point, we now have all of our hardware and should not be blocked by missing components.

While waiting for the RTC, the custom components of the irrigation controller have been manufactured and wired together into a working prototype (pictured below).

The major accomplishment was solidifying the irrigation algorithm. We are working with four sensors and tracking change over time. The first step was identifying operating parameters:

- Time
    - Tracks HH:MM:SS, Weekday MM/DD/YY
    - Notes: format and structure of data is user defined.

- Temperature
    - Format: whole degrees in Celsius
    - Limitation: DHT11 always provides whole numbers in the form of a float.
    - Notes: Hotter implies the necessity of watering sooner.
- Humidity
    - Format: percentage as an integer
    - Limitation: DHT11 always provides whole numbers in the form of a float.
    - Notes: High humidity would delay the need for watering even with high temperature.
- Light
    - Format: lux as an integer
    - Notes: Higher numbers imply more light (sunny conditions) exists, and may require watering more often.
- Soil Moisture
    - Format: continuity as an integer
    - Notes: Ranged between 0 and 1023 where 0 is completely wet and 1023 is completely dry. If soil is already moist, watering can be delayed.

From that, the parameters of the Arduino-based controller are clearly established:

- Outputs: Report zone number, temperature, humidity, light level, and soil moisture.
- Inputs: Receive a scheduled time to start watering, and watering duration.

The controller's duty is to periodically send sensor data, listen for scheduling info, and check the current time to determine if it's time to start watering according to a previously received irrigation schedule.

The command station's duty is to receive sensor data, interpret it, and determine when to begin irrigation. For this determination, each sensor is considered to have two states where a user-defined threshold will determine the division point between the two. The mapping is as follows:

	0	1
Temperature (A)	Not Hot	Hot
Humidity (B)	Not Humid	Humid
Light (C)	Not Sunny	Sunny
Soil Moisture (D)	Not Moist	Moist

For any combination of the four inputs, there would be one output: irrigate, or do not irrigate. To determine the irrigation algorithm, each combination of conditions was evaluated to determine if watering was necessary. From that, the following truth table was formed:

A	B	C	D	Output X
0	0	0	0	1
0	0	0	1	0
0	0	1	0	1
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	1
0	1	1	1	0
1	0	0	0	1
1	0	0	1	0
1	0	1	0	1
1	0	1	1	1
1	1	0	0	1
1	1	0	1	0
1	1	1	0	1
1	1	1	1	0

It is only necessary to focus on a single state, in this case, when to water (output x is 1). The algorithm becomes a general form of this truth table, which is expressed in the Boolean equation:

X = ~A~B~C~D + ~A~BC~D + ~ABC~D + ~ABC~D + A~B~C~D + A~BC~D + A~BCD + AB~C~D + ABC~D

Or, more easily with this same equation, after simplification:

X = ~B~D + C~D + A~D + A~BC

Thus, recommend irrigation any time when the following conditions persist:

- Dry air and dry soil, or
- Sunny day and dry soil, or
- Hot air and dry soil, or
- Hot and dry air, and sunny.

Sensor readings will be collected periodically from the controller and each reading will be evaluated on the command station to form a recommendation to schedule irrigation or not, depending on the algorithm. The average of these recommendations are used to determine if there is a scheduled AM or scheduled PM irrigation necessary. If the average ratio of recommendations to water over the time period prior to the potential scheduled PM irrigation time is above 50%, the command station will instruct the controller to water. Example:

Report	Watering recommendation
Period1	False
Period2	True
Period3	True
Period4	True
Period5	False

The average over the 5 report periods is 60%, so irrigation would be scheduled.

The instruction to begin irrigation must also pass through the following edge-case checks:

- The current temperature is not below a user-defined threshold.
- There has been a significant rainfall during the current reporting period.

As there is no rain sensor, the delta between the minimum soil moisture and maximum soil moisture content is evaluated. If the delta is large, it is assumed that there was rainfall and any scheduled irrigation is canceled for this cycle.

System picture: