PROJECT ALIN

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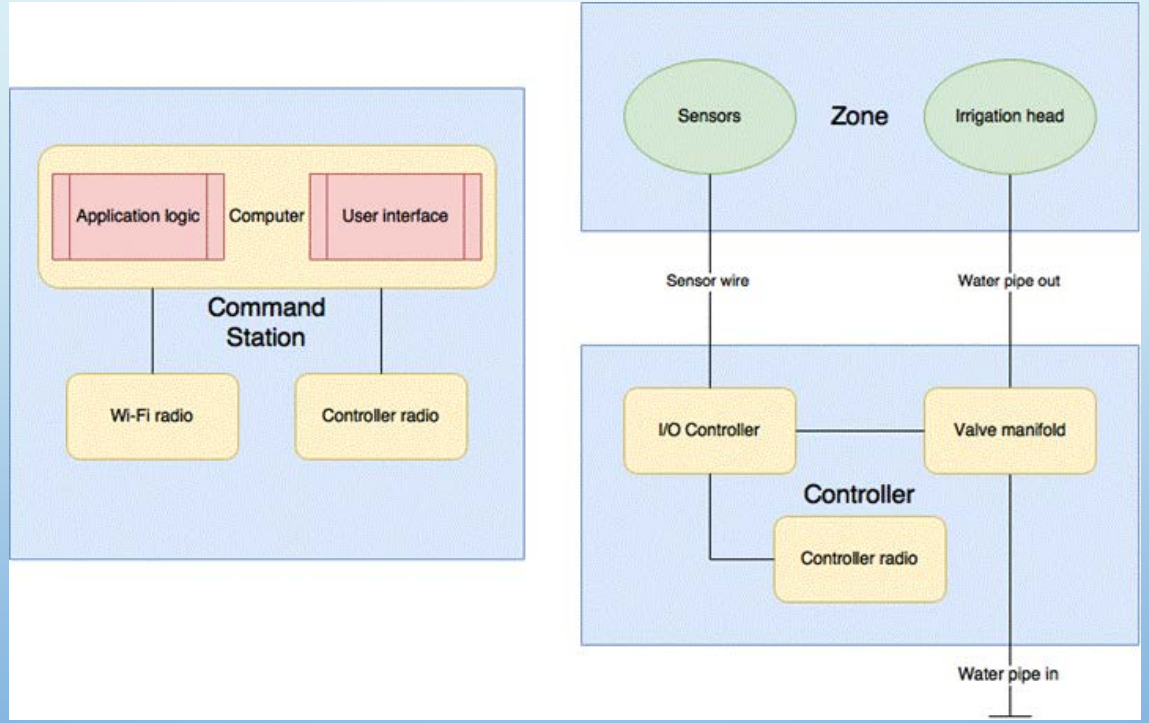
AUTOMATIC LAWN IRRIGATION NETWORK

Background and Goal

- System to monitor environment to activate sprinkling when needed
- Soil moisture sensor to alert system when to water
- Multiple zones that could individually dictate their own watering needs
- Additional sensors (light, temperature, humidity) to better inform the system
- Web based interface to allow user interaction with the system

SYSTEM OVERVIEW



HARDWARE: CONTROLLER

Basics:

- Arduino-based
- Transmits sensor data periodically and on demand
- Receives scheduled irrigation events
- Opens, closes, or toggles valve states on demand, or by schedule

Features:

- Wall-mounted weatherproof enclosure
- Battery backed real-time clock for accurate scheduling
- XBee 900MHz radio (zigbee) connection to command station

HARDWARE: VALVE MANIFOLD

Basics:

- One controller handles multiple zones
- One valve per zone
- Relay controlled

HARDWARE: SENSOR POD

Basics:

- Four sensors for each zone
- Temperature
- Humidity
- Light
- Moisture

Features:

- Ventilated weatherproof enclosure
- Glass lid to prevent UV discoloration for optical sensor

HARDWARE: COMMAND STATION

Basics:

- Raspberry Pi based
- Receives sensor data from all zones and interprets results
- Sends out irrigation schedules
- Allows direct user interaction to configure and control system

Features:

- Provides a web interface over WiFi
- Irrigation algorithm tuning, sensor readings, and schedule history
- XBee 900MHz radio (zigbee) to potentially multiple controllers

COMMAND STATION: SCHEDULING ALGORITHM

The watering schedule is affected by the following conditions:

- Time of day
- Amount of direct sunlight being received
- Temperature and humidity
- Soil conditions

Under what conditions should we irrigate?

SCHEDULING ALGORITHM CONT.

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

$X = \sim B \sim D + C \sim D + A \sim D + A \sim BC$

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

FINAL SCHEDULING ALGORITHM

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 are collected over a period of time to determine if irrigation should be scheduled.

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

RADIO COMMUNICATION: SENDING

14 implemented radio command codes

Sends:

- Acknowledgement of unrecognized commands
- Acknowledgement of remote command success or failure.
- Status of a zone's valve (open or closed)
- Sensor data for a zone
- Automatic retransmission on failure

RADIO COMMUNICATION: RECEIVING

Receives:

- Command to evaluate and report on a zone's valve state (open or closed)
- Open, close, or toggle the valve state for a zone
- Command to poll sensor data on demand for a zone
- Command to poll all sensors on demand
- Command to set irrigation schedule

RADIO COMMUNICATION: PAYLOAD

Format:

- Payload information is transmitted as literal values
  - Example: 1023 is four bytes long, sent as characters ‘1’ ‘0’ ‘2’ ‘3’

Structure:

- The first element is the identifier code.
- Additional elements are necessary when the code format requires them.
- Data elements are delimited with a comma
  - Example: 50,1,138,22,45,1023

RADIO COMMUNICATION: DATA SPECIFICATION

Code	Code, HEX	Code, DEC	Additional Payload	Notes
C_ACK	0x00	0		Response sent when a command is received but not recognized.
C_SUCCESS	0x01	1		Response sent when a command is received, understood, and is executed.
C_FAILURE	0x02	2		Response sent when a command is received, understood, but does not have valid parameters.
C_GET_VALVE_STATE	0x10	16	Z	Request the valve state for a zone Z. Generates a C_VALVE_DATA response.
C_SET_OPEN_VALVE	0x11	17	Z	Instruct the valve open for a zone Z. Generates a C_SUCCESS response.
C_SET_CLOSE_VALVE	0x12	18	Z	Instruct the valve close for a zone Z. Generates a C_SUCCESS response.
C_SET_TOGGLE_VALVE	0x13	19	Z	Instruct the valve position (open/close) to toggle for a zone Z. Generates a C_SUCCESS response.

HARDWARE COSTS

UWB provided:	
Controller, command station, sensors:	$315
Additional purchases:	
Construction materials (Home Depot)	$29
Enclosures (Fred Meyer)	$11
RTC and additional electrical materials (Amazon)	$47
Total	$402

SCHEDULING ALGORITHM: DEMO

Normally, conditions are collected throughout the day.

Revised algorithm for demonstration:

- Evaluates the average of the last four sensor readings
- Compares averages against sensor thresholds
- Concentrating on soil moisture and brightness
- Schedules irrigation one minute in the future