IoT-based Precision Irrigation with LoRaWAN Technology Applied to Vegetable Production

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Introduction

Agriculture accounts for 80% of water use in the US.

Deficit or excess of water affects yield and quality of vegetables.

Conventional irrigation is based on experiences and time availability.

Precision irrigation decreases cost of water and manpower, and improves crop yield and quality.

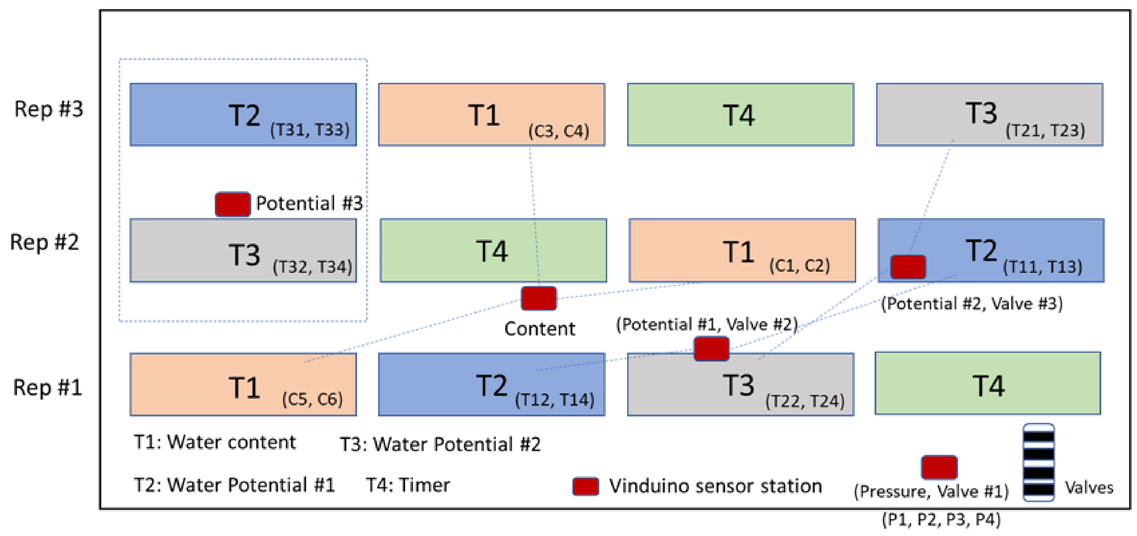
Internet of Things (IoT) makes farmers monitor the field and apply irrigation online.

LoRaWAN, a new network technology, is not widely used for vegetables irrigation.

Technology	Network type	Frequency	Range	Data rate	Power	Security
LoRaWAN	LPWAN	915 MHz	10 km	0.3-50 kbps	10mW	AES 128 bit
LTE	GERAN/UTRAN	700-2600 MHz	10 km	0.1-1 Gbps	1 W	3GPP 128-256 bit
Wi-Fi	WLAN	2.4, 3.6, 5 GHz	100 m	6-780 Mbps	1 W	WEP, WPA, WPA2

Materials and Methods

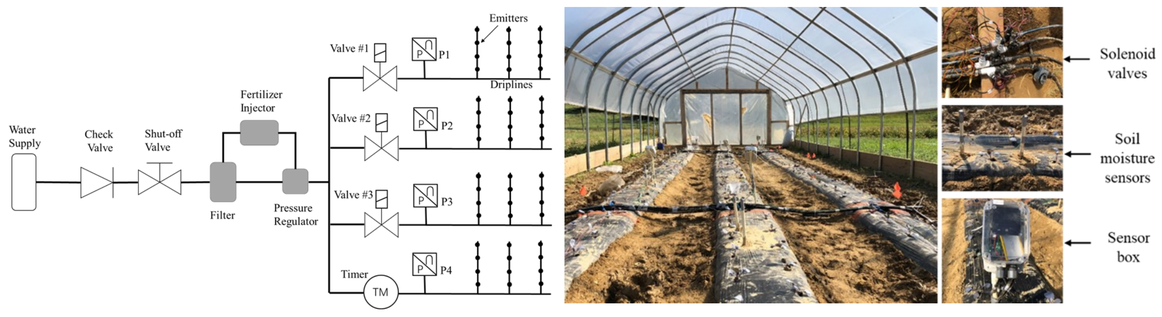
Experimental Setup



Content: C1, C2, C3, C4, C5, C6 are water content sensors, odd numbers are at 15 cm, and even numbers are at 30 cm.
Pressure: P1, P2, P3, P4 are pressure sensors (psi) for treatment T1, T2, T3, T4 respectively. Valve #1 is in this box.
Potential #1: T11, T12, T13, T14 are tension sensors, T11, and T12 are at 15 cm, and T13 and T14 are at 30 cm. Valve #2 is in this box.
Potential #2: T21, T22, TS23, T24 are tension sensors, T21 and T22 are at 15 cm, and T23 and T24 are at 30 cm. Valve #3 is in this box.
Potential #3: T31, T32, T33, T34 are tension sensors, T31 and T32 are at 15 cm, and T33 and T34 are at 30 cm.

Test crop: Red cabbage (*Brassica oleracea* cultivar Omero F1)

Irrigation system setup



4 main pipelines for 4 treatments.

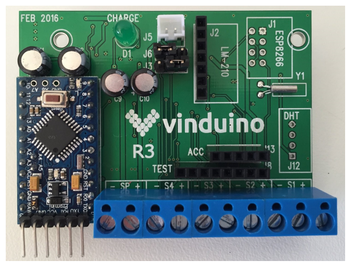
3 beds for 3 replicates.

0.60 m wide, 1.8 m apart center to center, mulched with black polyethylene film.

Pressure regulated to 15 psi.

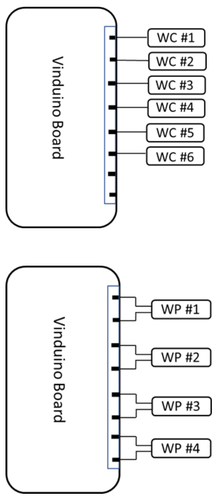
Pressure sensors measure the water pressure in pipes, indicate if water is on.

Sensor system setup



Control board

Supports 8 sensor ports and an irrigation unit

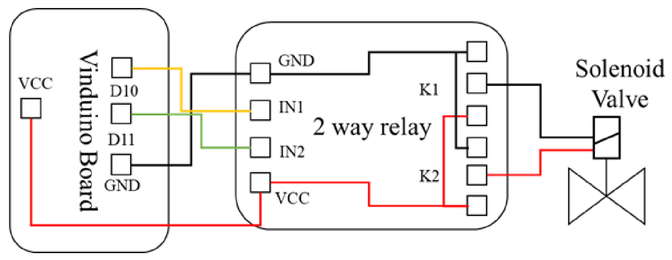


SWC sensors

Pressure sensors

SWP sensors

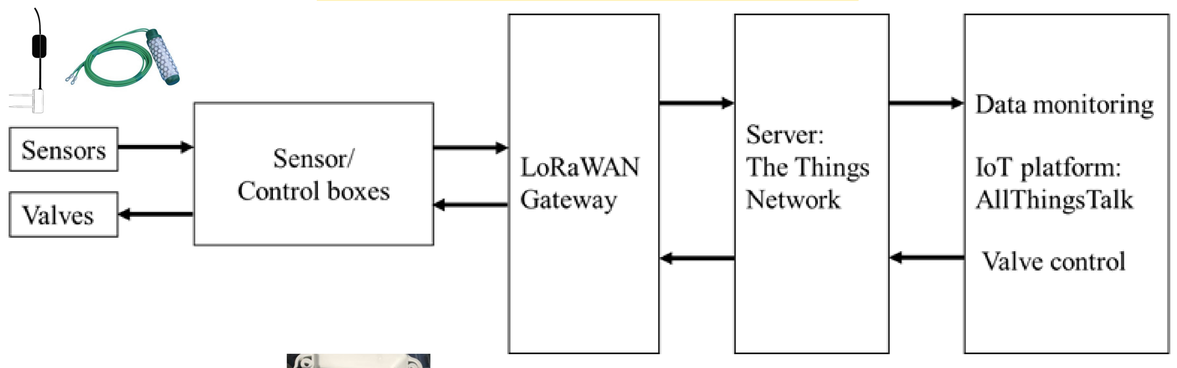
Irrigation valve control



T1, T2, and T3 used solenoid valves.

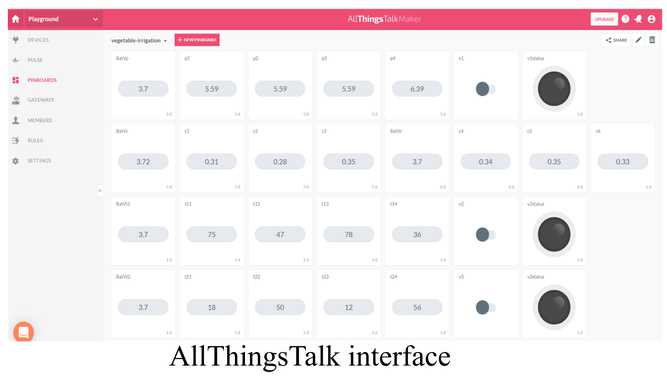
T4 used timer.

IoT system and data collection



THE THINGS NETWORK

AllThingsTalk by ALSO



AllThingsTalk interface

Read battery voltage, SWC, SWP, pressure, and valve status.

Control valves by switching the button.

Notify farmers when thresholds are reached by mobile app.

Results

Feasibility of the IoT system

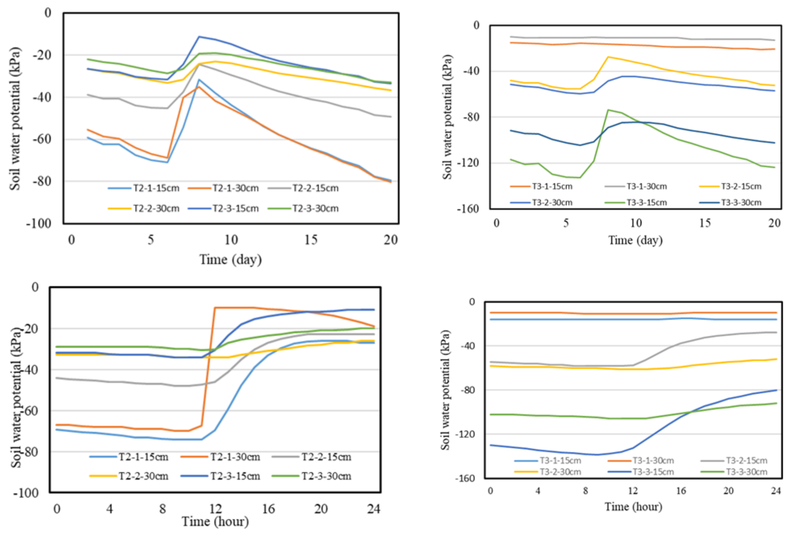
Read sensor data and control valves online stably.

4.3% data loss with a 300 m distance from gateway to sensors. May caused by obstacle of walls, long distance, and gateway performance.

Most sensor boxes worked continuously without changing battery. SWC Sensor box often went down and had wrong readings because of false continuous power supply.

Soil moisture monitoring with IoT system

No production data because of no water supply in freezing winter.



SWP of T2 and T3

Start on 11/20/2019

After irrigation on Day 6, sensor readings increase and then gradually decrease.

24 hours data on Day 6.

It took a few hours for the sensor readings to be stable.

Conclusion

The system can successfully read sensors data and control valves online with a acceptable data loss and low power consumption. SWP sensors work well for the system. But there are problems with SWC sensors power supply.

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