Internet of Things (IoT)-based Precision Irrigation with LoRaWAN Technology Applied to Vegetable Production

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Importance of Precision Irrigation

- Agriculture consumes approximately 80% of water use in the United States.
- Conventional Irrigation: based on experiences, over- or under-irrigation, low water usage efficiency, nitrogen loss.
- Precision Irrigation: determine when and how much to irrigate, which can save water and increase crop production.

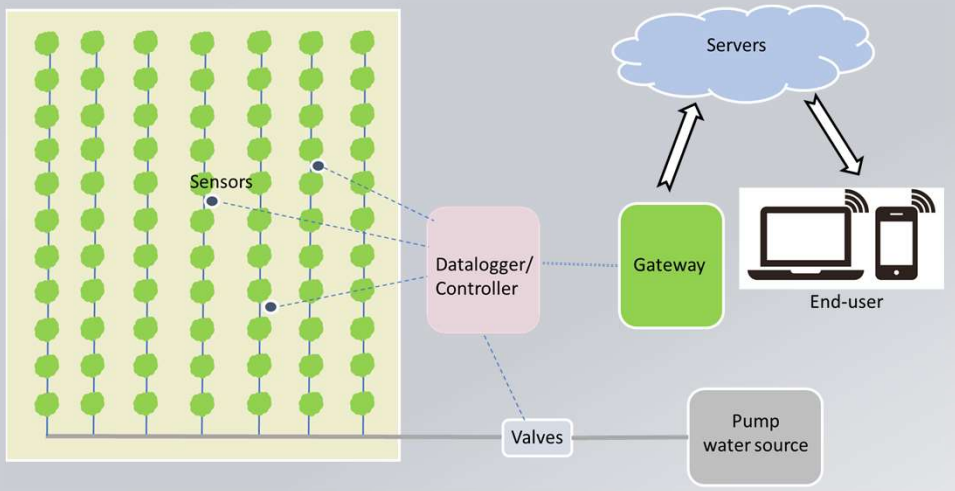

Photo: Rayies Altaf


Photo: FarmersTrend, 2017

Internet of Things (IoT) for Irrigation

❖ IoT system

- Access to sensor data remotely
- Analysis of sensor data
- Remote/automated irrigation control

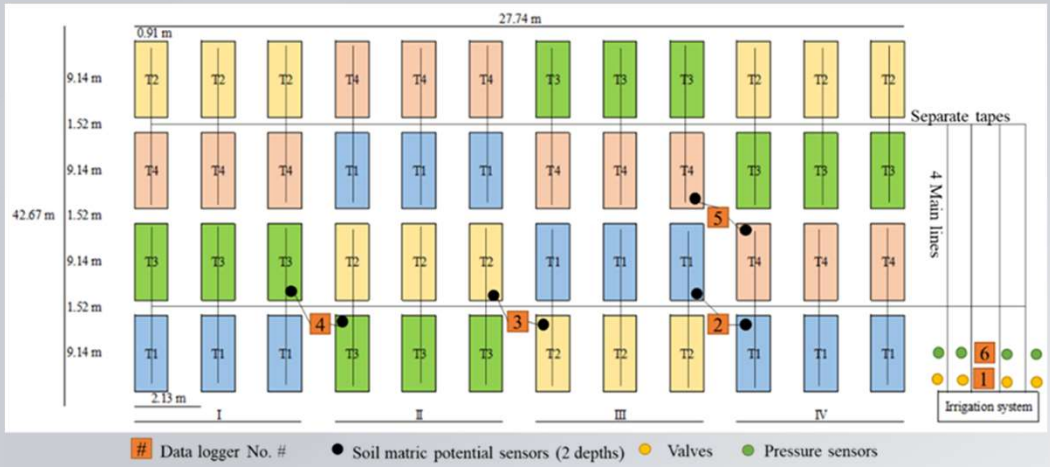


❖ Networks for IoT system

- Wi-Fi, Bluetooth, ZigBee, Sigfox
- Cellular network (GPRS, EDGE, LTE), **LoRaWAN**

Experiment Setup

N



Experiment Site

- Tomatoes open field at Rock Spring (Furnace, PA)

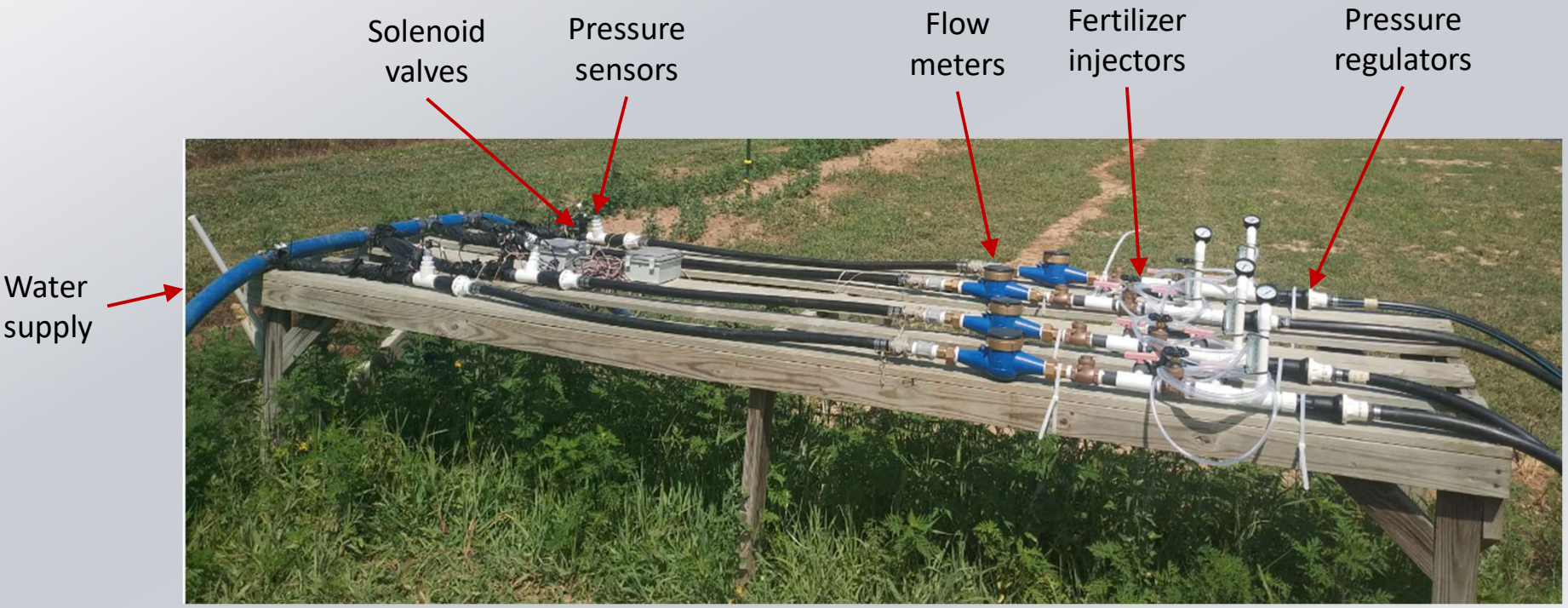
Treatment

- T1: ET-based (ET) (12 mm)
- T2: MP-based, -60 kPa (MP60)
- T3: MP-based, -40 kPa (MP40)
- T4: GesCoN-based (GesCoN)
- 4 replications, RCBD

GesCoN

- GesCoN is a decision support system developed by the University of Foggia (Italy), which provides daily ET_0 and suggestions for irrigation and fertigation.

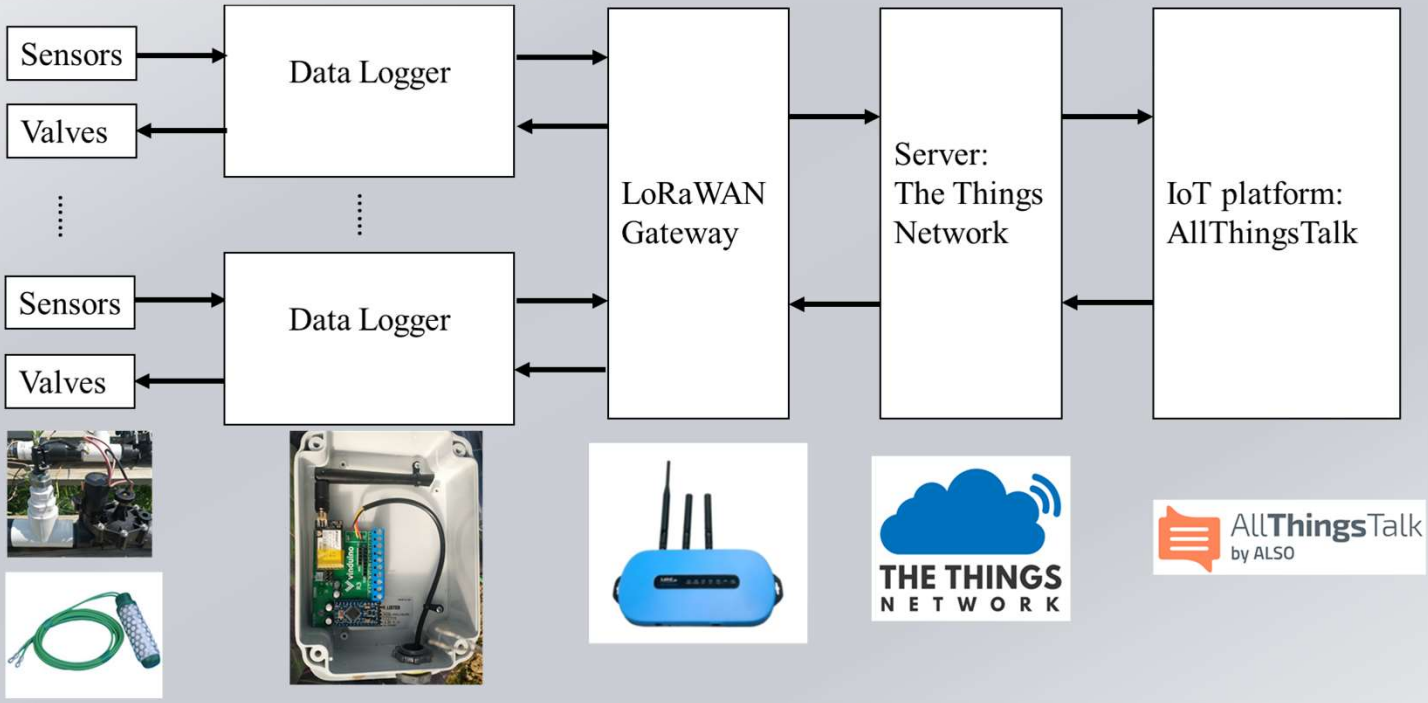
Irrigation System Setup



Major Components

- 16 Soil MP sensors
  - Watermark 200SS-5, Irrometer, Inc.
  - Installation depths: 20/40 cm
- 4 Pressure sensors
  - 5V, 0-1.2 MPa
- 4 DC latching solenoid valves
  - PGV Series 1 inch
- 6 Data loggers
  - 4 – MP sensors
  - 1 – Pressure sensors
  - 1 – Solenoid valves

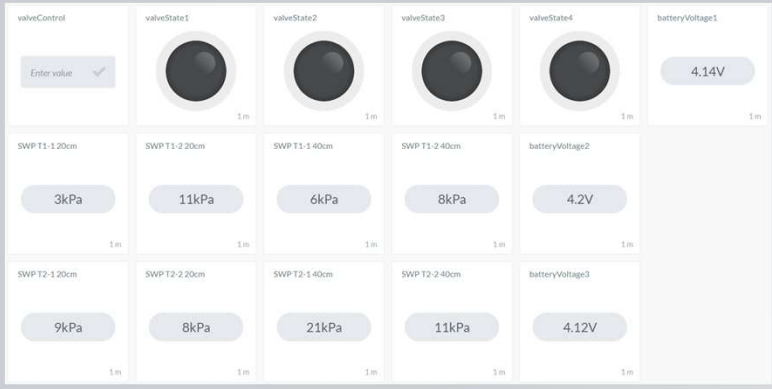
IoT System Development



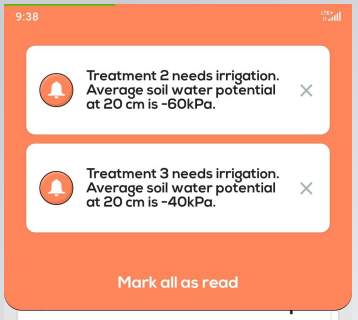
IoT System Interface

❖ Data chart

❖ Pinboard



❖ App notification



Harvest and Evaluation

- Tomatoes planted on 5/21/2020
- Data record started on 6/25, 35 Days after transplanting (DAT).
- Harvest on 78, 90, 103, 113, and 125 DAT.
- Only harvest 10 representative plants in the middle bed from 20 plants.
- Crop yield and water use efficiency were analyzed.

Results: Yield

Treatment	Fruit Fresh Weight (Mg/ha)					
	XL	L	M	Cull	TMY	TY
T1	46.35 bc	4.52 b	3.34	25.73 ab	**54.21 bc**	79.95 ab
T2	52.71 ab	6.46 a	3.26	23.66 b	**62.43 ab**	86.09 a
T3	38.16 c	5.43 ab	3.75	27.49 a	**47.34 c**	74.83 b
T4	56.72 a	5.95 a	3.52	20.00 c	**66.19 a**	86.20 a
P-value	0.01	0.04	0.66	0.002	**0.01**	0.06

XL = Extra-Large, L = Large, M = Medium, Cull = Unmarketable,

TMY= Total marketable yield, TY = Total yield

- ET +0%
- MP60 +15.2%
- MP40 -12.5%
- GesCoN +22.1%

Results: Irrigation Water Use Efficiency (iWUE)

Treatment	Volume (m^3 ha^{-1})	iWUE (kg m^{-3})
ET	2440	22.22 b
MP60	2357	26.49 ab
MP40	1695	27.94 a
GesCoN	2339	28.38 a

- Total water usage
  - MP60 -3.4%
  - MP40 -30.5%
  - GesCoN -4.1%
- iWUE
  - MP60 +19.2%
  - MP40 +25.7%
  - GesCoN +27.7%

Conclusion – System Feasibility

- The IoT system with LoRaWAN technology monitored the sensors and controlled the valves successfully
- 5.5% signal loss
- Sufficient battery supply
- Minor misfunction of valve control

Conclusion – Crop Irrigation Evaluation

- For yield and iWUE, GesCoN was the highest, followed by MP60, then ET. However, MP60 has no significant difference from other two treatments.
- According to the results of MP60, the developed IoT-based system using LoRaWAN technology can be potentially used for precision and automatic irrigation application for practical vegetable production.

Acknowledgement

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Thank you!