Irrigation Scheduling Software Development

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Abstract. *Current developments in the next generation Wireless Sensor Networks (WSN's) allows for distributed irrigation control from a centralized basestation. This work presents several methods of irrigation control based on WSN's as well as the user interface to make it happen. WSN irrigation methods start with manual commands, moves onto node based irrigation, and then extends to a global based irrigation approach. The user interface needs to be able to configure the different modes while allowing users to monitor irrigation spatially as well as temporally. This work explores the tradeoffs in node software development to allow for optimal node performance. One of these innovations is a configurable pulse time for irrigation events. This system is deployed and being tested in different types of agricultural environments to help determine irrigation scheduling needs of various agricultural techniques. Developing new irrigation software that allows for clear and easy control is critical as new systems are fielded to improve the user experience and provide the requisite details to irrigate ideally.*

Keywords. WSN, wireless sensor networks, irrigation, control, intelligent, user interface, GUI, software, base station, basestation

Introduction

Irrigation control is a critical task in any growing operation. Wireless Sensor Network's (WSN's) can be used for increased irrigation precision while also reducing the work load of the irrigation manager [Majsztrik, Lichtenberg & Lea-Cox, 2012]. In this work a commercially available WSN system from Decagon Devices, Inc. is further developed to control irrigation solenoids and a new user interface [Kohanbash et. Al. 2012a] was developed to allow for easy and flexible data access, to help make sensor data actionable, and to allow irrigation to be managed from a centralized location.

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Irrigation Control

WSN's provide a unique platform for irrigation control. By nature a WSN system has many inexpensive nodes that are distributed in many locations. This is beneficial since agricultural sites may contain several hundred different crop species [Lea-Cox & Belayneh, 2012]. In many cases, including in this work, WSN systems also have a central basestation that is responsible for collecting all of the data from the nodes. These attributes make WSN systems ideally suited for irrigation control. A central basestation that is remotely accessible by the growers can be used to configure and monitor irrigation while each node is located near the irrigation zone that it is controlling. This interaction between a distributed control system and a centralized interface allows for advanced irrigation methods to be developed.

Hardware

The WSN node was developed by Decagon Devices, Inc. (Pullman, WA), based on its existing Em50R node. The Em50R was chosen as a base due to its reliability, ease of use, and wide array of compatible sensors [van Iersel, 2012]. Two new nodes (Fig. 1) were developed the nR5 and the nR5-DC. Both nodes are capable of reading from up to 5 sensors and have an onboard relay that can be used for controlling solenoids. The nR5 is capable of controlling 24VAC solenoids. After testing and fielding the nR5, growers wanted a node that was easier to deploy. A new node the nR5-DC node was developed which uses onboard power to control 12V latching solenoids, this advance allows growers to not run power to each irrigation site to control the solenoid, saving both time and money. The nR5-DC makes this system highly portable and allows growers to modify irrigation zones on the fly.

Fig 1. Inside of an nR5-DC node used for irrigation control. Solenoid wires can be seen to the right of the batteries [Lea-Cox & Belayneh, 2012].

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Irrigation Modes

There are four primary modes of irrigation available [Kohanbash et al. 2012b]. The first is a manual mode that allows growers to specify and "override" irrigation settings to manually command an irrigation event to occur. The second type is schedule based control. This approach is similar to existing schedule based controllers. The third type is local set-point control. This mode allows each node to control irrigation based on a specific soil moisture value using attached or "local" sensors. In all of the previous modes the settings are configured on the basestation and sent to the node where the node can then decide whether irrigation should occur, while the basestation is used to send the settings to the node it is not required after that as the node controls all irrigation functions. The final mode is called global control; this mode uses the basestation to actively control irrigation. Global control lets nodes control irrigation based on data from other nodes as well as from grower tools that are user configured. Grower tools take on the form of simple tools such as dew point, averages, vapor pressure deficit (VPD), and growing degree days (GDD) as well as more advanced tools [Kohanbash et. al. 2011] based on plant physiology [Bauerle et. al., 2006; Starry et. al., 2011; van Iersel et. al., 2010; Kim, 2012]. Some of these advanced growing tools allow plant models to use environmental conditions as inputs to determine if irrigation should occur.

Pulse Types

Another innovation is pulse types. Within each irrigation event, as defined by the four modes above, the user can control exactly how irrigation water is applied. For example a user can specify that an irrigation event should turn on for 60 seconds, turn off for 30 seconds, and then repeat that cycle 5 times for every event commanded (Fig. 2). This allows for micro-pulse irrigation [Lea-Cox & Belayneh, 2012; Kohanbash, et al. 2012] and other benefits such as allowing water pressure to build between irrigation applications and allowing the sensors time to measure soil moisture between events.

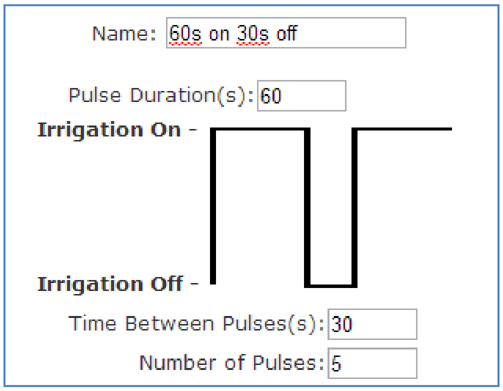

Fig 2. Segment from the user interface that lets users graphically define pulse types.

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Irrigation Monitoring

Irrigation control is important but knowing when and how much irrigation occurred is also critical [Majsztrik, Lichtenberg & Lea-Cox, 2012]. Within the sensorweb system there are multiple ways to view irrigation. The home page that provides a spatial view of the site can also show irrigation quantities by color coding the nodes (Fig. 3), the data view page shows not only the amount of irrigation used but the moisture value that the node is using for controlling irrigation. There is also a charting tool that lets irrigation events be plotted with other data (Fig 4). The previous methods for viewing irrigation requires a user to go to the basestation's interface and look at the data, this system also features alerts that can send an email or text message to users. The alert is user configurable and can be based on too much irrigation being applied, to little irrigation being applied, or a daily alert that specifies how much irrigation occurred. Alerts can also be used for sensor data and not just for irrigation values.

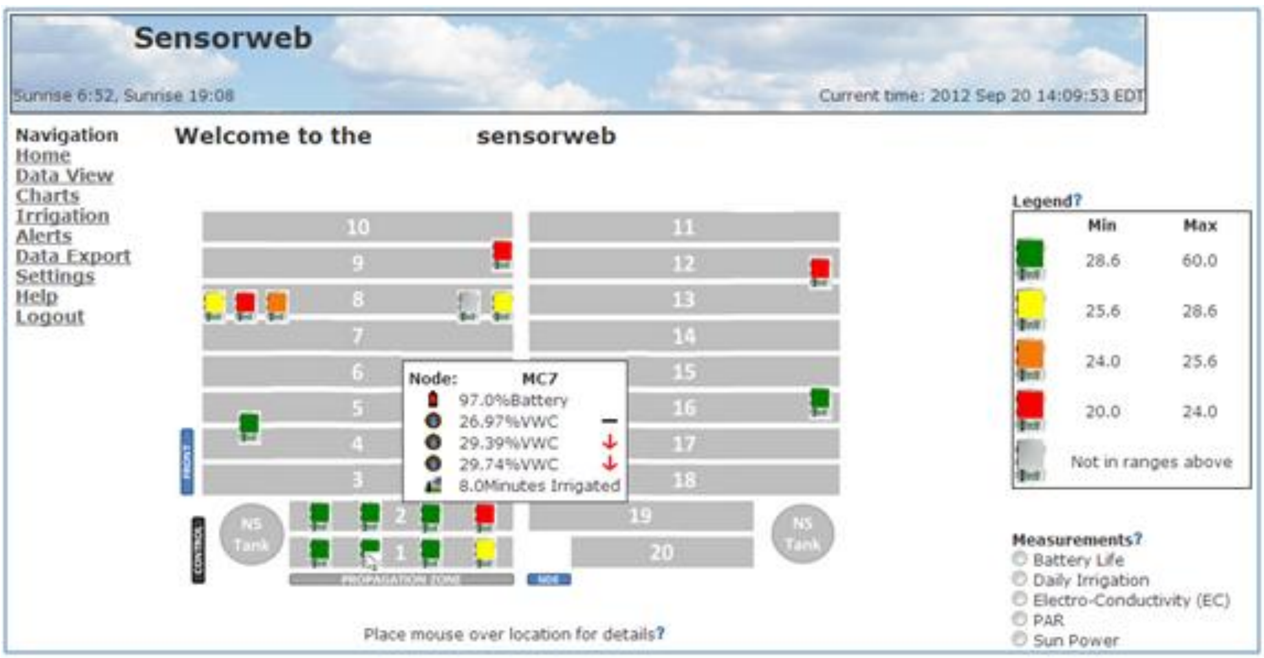

Fig 3. Spatial view showing data and color coded nodes. Irrigation can be seen in the pop-up box.

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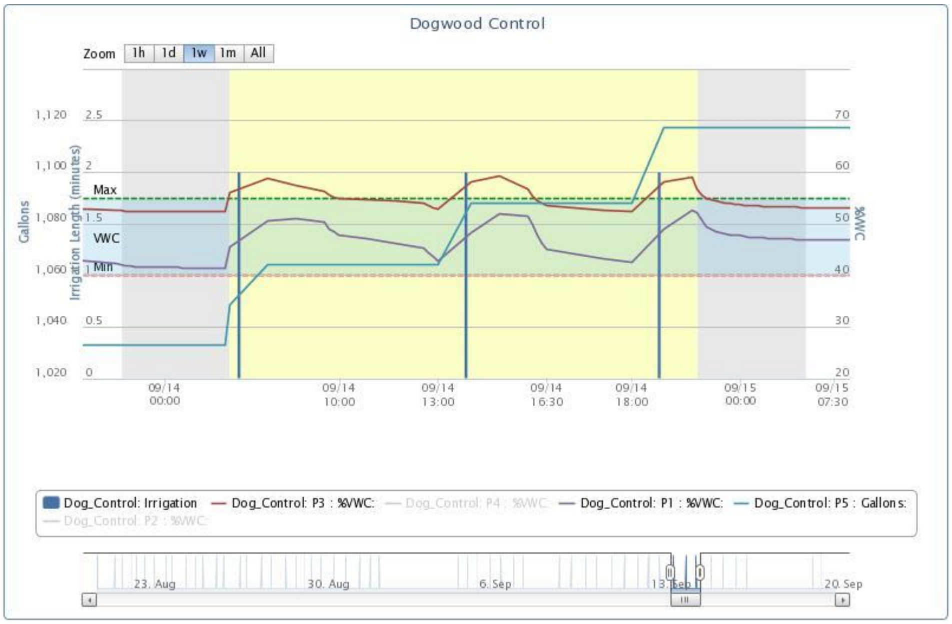

Fig 4. Chart showing blue vertical bars for irrigation and horizontal lines with soil moisture sensors (see Lea-Cox & Belayneh, 2012 for more information). The horizontal blue band is a user defined region for optimal moisture levels.

For configuring irrigation parameters an easy to use interface [Kohanbash et. al., 2012] was created as well as assistive tools such as showing all of the irrigation schedules on a single page and showing how many nodes are irrigating at a given time (Fig. 5).

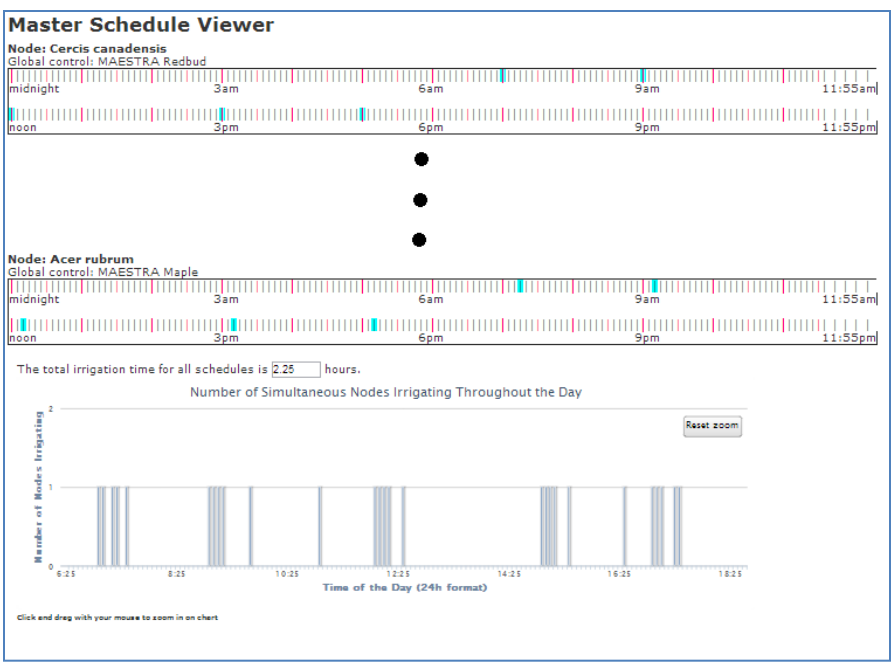

Fig 5. Image showing multiple schedules on one page for comparison and also a plot that shows all irrigation overlaid on each other.

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Error Detection

Error detection is another critical aspect that must be mentioned. The internal software on the node is able to detect many sensor faults. This is primarily done by comparing sensor values to the known range of valid sensor readings. The node is also able to send error messages to the basestation that are then displayed for the user. In the user interface bad sensor values are shown in red so that they are more noticeable to the user. While a lot of work has been put into error detection there are still certain errors that cannot be detected at this point. For example if a sensor gets pulled out half way and is still returning a value within its valid range the system cannot detect it.

Conclusions

Wireless sensor networks are a versatile tool for irrigation managers [Lea-Cox, 2012]. This system has been deployed at over a dozen sites throughout the county and has been used at various sites including greenhouses, nurseries, and orchards. The WSN model for irrigation allows direct integration of plant science models that allows the benefit and value of WSN based irrigation systems to be increased [Chappell & van Iersel, 2012]. Ongoing field work is being conducted that is quantifying the benefits of WSN based irrigation control (please visit http://smart-farms.net for more information).

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