Environmental Optimization of IRrigation Management with the Combined uSe and Integration of High Precision Satellite Data, Advanced Modelling, Process Control and Business Innovation

Info factsheet no 2: Wireless Sensors Networks in Precision Agriculture

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Introduction

Wireless sensor networks (WSN) are a relatively new and rapidly developing class of networks which can provide processed real time field data from sensors distributed in the field. The sensor nodes deployed on the field measure various atmospheric and soil parameters. These measurements can help in making decision on irrigation (automating, semi automating), fertilizer and pesticide applications, intruder detection, pest detection, yield prediction, plant disease prediction, fire detection, etc.

Hardware is currently an active research area carried out in universities around the world and in private companies. The possibilities in this field are enormous because of the increasing need to look for new sensors for different applications, the advances in miniaturization, components to be integrated, or new features to save energy. In this sense, **WSN technology clearly represents the most promising candidate to significantly improve current irrigation systems.** In combination with low-cost communication modules in sensor motes, the overall costs of WSN solution for smart irrigation application is driving the possibility for its widespread applications.

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Project website
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Community contribution
2.085.965, 00 €
Duration
January 2012- December 2014

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Wireless Sensor Networks for Smart Irrigation Systems

There are number of challenges identified for deploying effective WSN solution for smart irrigation applications. These challenges lead to identification of the set of requirements WSN solution should provide:

- **Sensitivity:** WSN output should be sensitive, i.e., susceptible to small changes in terms of soil moisture or plant demand,
- **Responsiveness:** WSN should be responsive; it should be able to provide continuous monitoring and respond rapidly (in real-time) to detected changes in order to maintain optimal water levels,
- **Universality:** WSN should be adaptable to different types of crops and different growth stages,
- **Robustness:** WSN should be robust against failures and serve as a reliable source of irrigation data,
- **Scalability:** WSN solution should be scalable and allow for initial small deployment and simple further extension towards middle-scale or large-scale deployments where necessary,
- **User-Friendly:** WSN interface towards the end-user should be intuitive, easy to use and should not require significant user training. Recent developments in smartphone applications and operative systems should serve as an excellent basis for user-friendly interface between the end-user and the WSN,
- **Actuator Powered:** WSN should represent not only sensing but acting solution as well (WSAN – Wireless Sensor and Actuator Network). WSAN is able to deliver fully automated solution, non-dependable on human labor which is expensive and potentially unreliable,
- **Energy Efficient:** Sensor nodes should be either battery-powered or preferable, should use some of the recently emerging energy harvesting solutions,
- **Reliable Communication:** WSN should provide reliable communication between sensor motes and a mote and the base station for a distances of the order of 1km which are relevant in agricultural large-field environment,
- **Low- Cost:** WSN solution should be inexpensive and cheap to maintain and operate. Sensor nodes should be easy to deploy and replace.

Soil moisture sensors for Smart Irrigation Systems

Apart from WSN solution being able to satisfy abovementioned requirements, the appropriate use of soil humidity sensors suitable for a given application is also very important. Measuring soil moisture is typically performed either directly or by the so called water balance calculations and these two approaches are the most frequent for automated irrigation applications.

The first approach, based on **direct soil moisture measurements** is the most common approach with the use of various types of soil moisture sensors of either soil water potential (tensiometers), or soil water content (capacitance sensors or sensors based on time-domain reflectometry – TDR sensors).

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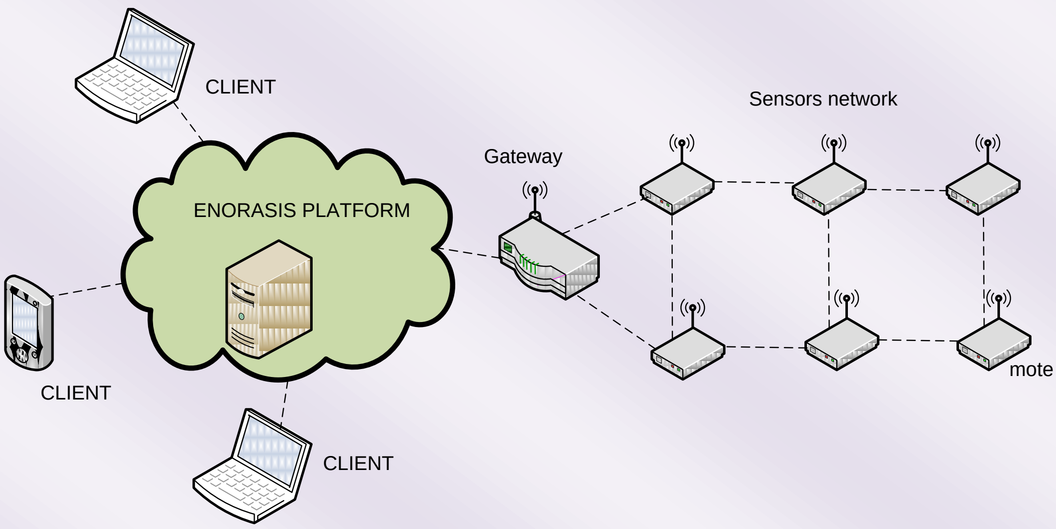
Sensors that measure water content are typically more accurate than sensors that measure water potential. Both approaches are very frequent in practice as they are easy to deploy and can be sufficiently accurate, thus justifying availability of a number of commercial solutions based on this type of sensors. However, any soil moisture sensor technology available today suffers from locality of measurements, whereas the real situation around the plant root is typically much more heterogeneous. This drives the need for sensor array that could successfully capture the variable soil moisture nature. Depending on the soil heterogeneity, this solution might have a significant drawback in terms of the required sensor density and thus significant deployment costs.

The second approach requires data to obtain soil moisture information indirectly, via **water balance calculations**. To this end, a set of sensors or measurements providing data such as rainfall and applied irrigation at one side of equation, and evaporation, run-off and drainage on the other side of equation, are required. These data can be directly measured or some appropriate available approximations could be used. However, the resulting measurements are not as accurate as direct soil moisture measurement methods.

Smart Irrigation WSN architecture

WSN-based solution for smart irrigation deploys a set of sensor and actuator (such as water valve) nodes across the irrigated area. WSN/WSAN nodes measure soil humidity and forward acquired information to the central data base over the gateway device which usually serves simultaneously the role of WSN sink as well as the gateway towards the external network, most frequently mobile cellular network enabled packet services such as GPRS/EDGE. The topology of sensor network is most frequently the simplest star/tree topology, although more involved mash configurations are also possible.



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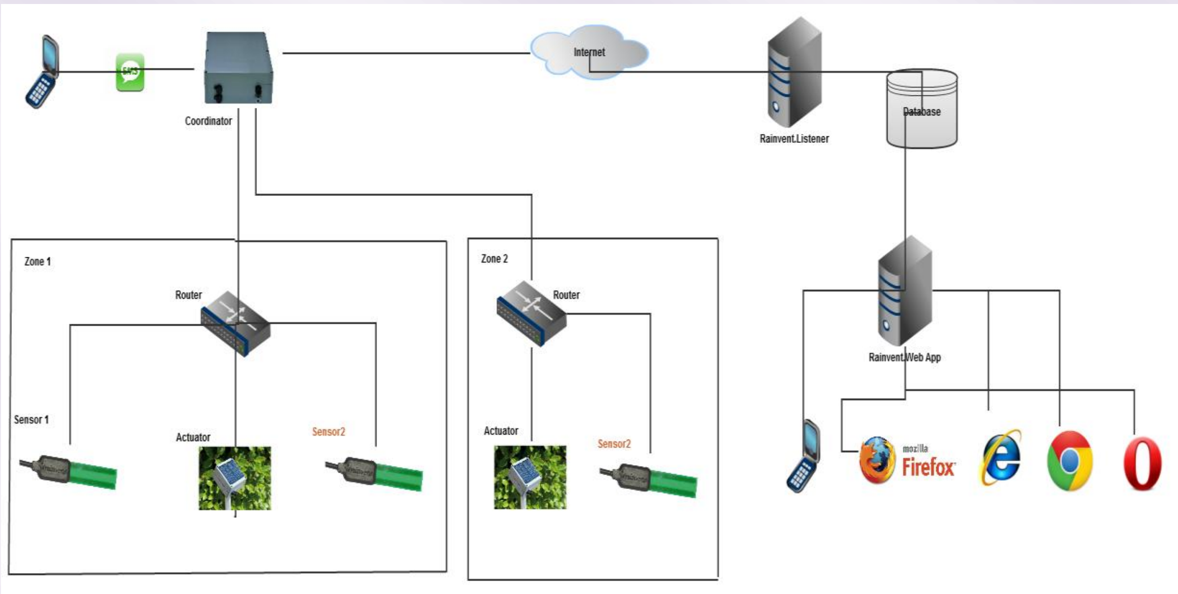
Data from sensors are usually collected periodically in a push manner, i.e., the sensor node is programmed to send sensor measurements after expiration of each time period. Usually, the period of data acquisition and reporting is controllable by end user and may allow change in time-resolution of measured data. Also, data acquisition period at sensor nodes and data reporting period may differ, where typically, sensor node send averaged values of recent measurements due to the fact that communication costs significantly exceed sensing and data acquisition costs. Usual sensing period is of the order of one minute. Reducing reporting period duration drastically increases battery life, but affects the time resolution of measurements which calls for carefully selected reporting period. It is highly desirable to select the operating parameters so as to extend battery life to a time span of at least one year, if not several years.

Apart from soil moisture sensors, sensor nodes are typically equipped by a multitude of other sensors such as soil conductivity sensors, soil and air temperature sensors, air humidity sensors, anemometers to include effects of wind on evaporation, sunlight intensity sensors, etc.

WSN in smart irrigation- The practice: Rainvent™ Smart Irrigation System

Although smart irrigation is very active research area, there are still only a limited number of commercial WSN-based solutions available in the market. In the following, the solution designed by **Teknoset** (www.teknoset.com), one of the ENORASIS project partners is presented.



Rainvent™ has two main parts: **Web server** and **Embedded system**. The Embedded system is the main part of the application and can work independently of the Web server.

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It has four main components:

- **Sensor(s),**
- **Actuator(s),**
- **Router(s),** and
- **Coordinator.**

The **Coordinator** can be thought of as the controller and brains of the system. The Coordinator makes all the decisions, communicates with the Web server, interpretes received commands and issues these commands to the appropriate devices. The Router relays the signals so system can be installed on large areas.

The system has two working modes:

- **Manual** mode, and
- **Auto** mode.

The Server part consists of the Listener application which interacts with the Embedded system and a front-end Web application. Rainvent^{TM} Web application allows the user to see fields, zones, devices and change their parameters, turn on/off valves, monitor soil moisture levels, and export log data from the fields. Web application also provides graphical and csv (comma separated values) based reporting. The Listener application is responsible for the communication between fields and the Web application.

The Web server part has a web-based Application Programming Interface (API) to provide access to the system through 3rd party applications. 3rd party applications interact with Rainvent^{TM} via Web Service calls.

The main components of the system are the following:

RainventTM controller

Rainvent^{TM} Control Unit is a smart irrigation controller that wirelessly communicates with Sensor Boxes, Actuator Boxes, and Valve Boxes. Rainvent^{TM} Controller Unit collects measurements from Sensor Boxes in a pre- defined time interval, and sends commands to a Valve Box or an Actuator Box according to user defined custom scenarios. The Control Unit stores all logs and provides reports on demand from the user. In addition, the Rainvent™ Control Unit provides remote control and monitoring via SMS or Internet.

RainventTM Sensor Box

Rainvent™ Sensor Box can be connected to two sensor channels that are compatible with Rainvent™ Moisture Sensors and one (optional) Relative Humidity and Ambient Temperature sensor.

Rainvent™ Sensor Box measures soil moisture, temperature and humidity levels and transmits the measurements to the Control Unit. Rainvent™ crop database allows the choice of the crop type and determines the optimum soil moisture levels. Temperature and Relative Humidity measurements are used to calculate dew point and provide early frost warnings.

RainventTM Valve Box

Rainvent™ Valve Box implements the irrigation schedule by fulfilling on/off commands for a particular valve.

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Learn more about ENORASIS project

Visit the ENORASIS knowledge web portal www.enorasis.eu for information about the project and project activities, and the ENORASIS portal knowledge base to get access to useful material about technological aspects (wireless sensor networks, remote sensing data, GIS applications), modelling aspects, Water Governance Legal and other issues, and irrigation management.

All project deliverables of public dissemination level as well as project dissemination material (leaflets, posters etc.) are available in www.enorasis.eu/download.

Also join ENORASIS in social media to take part in our web-community of irrigation management interested stakeholders and get informed about all project news and activities.

: ENORASIS FP7 Project (page)

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