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An autonomous intelligent gateway infrastructure for in-field processing in precision viticulture

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ABSTRACT

Wireless sensor networks have found multiple applications in precision viticulture. Despite the steady progress in sensing devices and wireless technologies, some of the crucial items needed to improve the usability and scalability of the networks, such as gateway infrastructures and in-field processing, have been comparatively neglected. This paper describes the hardware, communication capabilities and software architecture of an intelligent autonomous gateway, designed to provide the necessary middleware between locally deployed sensor networks and a remote location within the whole-farm concept. This solar-powered infrastructure, denoted by iPAGAT (Intelligent Precision Agriculture Gateway), runs an aggregation engine that fills a local database with environmental data gathered by a locally deployed ZigBee wireless sensor network. Aggregated data are then retrieved by external queries over the built-in data integration system. In addition, embedded communication capabilities, including Bluetooth, IEEE 802.11 and GPRS, allow local and remote users to access both gateway and remote data, as well as the Internet, and run site-specific management tools using authenticated smartphones. Field experiments provide convincing evidence that iPAGAT represents an important step forward in the development of distributed service-oriented information systems for precision viticulture applications.

1. Introduction

Precision agriculture (PA) and precision viticulture (PV) involve using electronic, communication and information technologies to collect large amounts of data in the field to use in site-specific crop management (Stafford, 2000). Wireless sensors are considered the best technology to gather the massive amounts of data needed, for example, to understand production variability (Camilli et al., 2007) or estimate growth profiles (Moreenthaler et al., 2003). Arranged to form widespread *ad hoc* networks, known as wireless sensor networks (WSN), they have been used to assist in spatial data collection, precision irrigation, variable-rate technology and in supplying data to farmers (Lamb and Bramley, 2001; Wang et al., 2006). However, these technologies are still far from being firmly established in agricultural practice and farming enterprises (Kitchen, 2007).

The volume and nature of the data introduce a significant challenge in the development of WSN in PA. Massive amounts of raw data do not necessarily yield proportional amounts of information. There are obvious difficulties in interpreting the data involved in order to reach a better understanding of the causes of variability and in proposing sound strategies for field variability management (Murakami et al., 2007; Rundel et al., 2009; Bramley, 2009). The nature of the data also brings difficulties: the data are heterogeneous and the management of heterogeneous data sources poses specific problems (Plant, 2001). The task of getting meaningful information from many disparate sensors is not trivial (Ibrahim et al., 2005).

Energy and networking issues need also to be considered. Typically, a large and remote agricultural area has to be covered with small data acquisition devices, which must harvest energy to run (Morais et al., 2008b). Each device faces severe power constraints, and the coverage of large areas may only be possible if several levels of internetworking are combined to achieve a higher level of network performance and scalability.

To better manage the data and address the networking and scalability issues we propose to carry data aggregation and data

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