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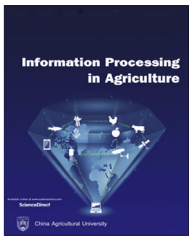

Wireless data management system for environmental monitoring in livestock buildings

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ABSTRACT

The impact of air quality on the health, welfare and productivity of livestock needs to be considered, especially when livestock are kept in enclosed buildings. The monitoring of such environmental factors allows for the development of appropriate strategies to reduce detrimental effects of sub-optimal air quality on the respiratory health of both livestock and farmers. In 2009, an environmental monitoring system was designed, developed and tested that allowed for the monitoring of a number of airborne pollutants. One limitation of the system was the manual collection of logged data from each unit. This paper identifies limitations of the current environmental monitoring system and suggests a range of networking technologies that can be used to increase usability. Consideration is taken for the networking of environmental monitoring units, as well as the collection of recorded data. Furthermore, the design and development of a software system that is used to collate and store recorded environmental data from multiple farms is explored. In order to design such a system, simplified software engineering processes and methodologies have been utilised. The main steps taken in order to complete the project were requirements elicitation with clients, requirements analysis, system design, implementation and finally testing. The outcome of the project provided a potential prototype for improving the environmental monitoring system and analysis informing the benefit of the implementation.

1. Introduction

Air quality is an important factor that needs to be considered in livestock production, especially when livestock is kept in enclosed buildings. There are a number of airborne pollutants found in piggery buildings that are of concern. The most notable of which are ammonia (NH_3), carbon dioxide (CO_2), airborne particles, and microorganisms [1]. When these pollutants are above certain levels, they can have detrimental effects on the health and welfare of exposed humans and livestock, can reduce the production efficiency of livestock, and can have a negative impact on the external environment [2]. In order to determine if air pollution is an issue, as well as what actions need to be taken, the air quality within a live-

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stock buildings need to be monitored. In 2009, an *Environmental Monitoring System* (EMS) was designed, developed and tested in Australia. The development of the EMS was born from the need for an accurate, low-cost user friendly kit for monitoring airborne pollutants, which would allow for air quality improvement strategies to be implemented [3]. The routine use of the EMS has the potential to improve building environments and reduce pollutant emissions by creating awareness of air quality issues amongst livestock farmers [2]. The EMS was developed with the key airborne pollutant found in piggery buildings in mind. Sensors allowed the recording of air quality components and portability was maintained in order for the unit to be taken to different livestock buildings. The unit was also field tested in working piggery buildings, which allowed for the assessment of operational/labour requirements as well as the capabilities of the system. Improvements in effectiveness and efficiency and reduced cost of the system gave it the potential to become a routinely used tool for the monitoring of air quality in the future.

However, there are a number of key limitations of the current EMS implementation. The main problem is the labour and time required to collect, collate and store data recorded by EMS units. An increase in ease and efficiency of these processes will increase usability of the system and therefore the potential for deployment and widespread use. In order to resolve the problem, telecommunication technology can be used to create a system that will automate the data collection and management process. This study investigates how the current EMS can be improved using telecommunication technologies. In the first part current networking technologies are discusses and their suitability in livestock buildings is investigated. In the second part a specific prototype implementation for the existing EMS are discussed and evaluated. The key contributions of this work include an overview of available networking and data management technologies that can be used to build could-based environmental monitoring systems. In particular their application in the context of agricultural engineering is evaluated and practical implications for the design of could-based systems in this context are discussed. The paper also introduces a case study that demonstrates how such a system can be designed and build in practical terms. The discussions and the conclusions that are drawn are generic and apply to other systems in similar environments as well. The remainder of the paper is organised as follows: Section 2 discusses an example of an environmental monitoring system to provide the necessary background to provide constraint that inform the selection of suitable communication technology. Section 3 provides a tutorial style overview of technologies that can be used to provide network connectivity for environmental monitoring systems. Section 4 address alternative approaches to data management and Section 5 highlight implications for the overall system design. Section 6 introduces a requirements analysis and the system design. The prototype and testing are discussed in Sections 7 and 8. The paper concludes with results in Section 9.

2. Background and literature review

This section introduces current environmental monitoring system in more detail. The system has evolved over time undertaken a variety of upgrades and modifications since its origins as the BASE-Q system, such as those described in Clements et al. [4] and Saha et al. [5] The latest working EMS is discussed and its requirements and limitations are highlighted.

The *hardware* configuration of the current EMS unit is depicted in Fig. 1 and in detail described in Clements et al. [4]. The EMS unit is all contained within a small plastic hard case, which allows for ease of portability during transport and mounting when in use, as well as protecting the internal components from the operating environment. The gas monitoring subsystem allows for the monitoring of ammonia and carbon dioxide both inside and outside the livestock shed. The small size of the gas sensor modules allows for them both to be contained in a single air-tight chamber, which is supplied air by the single vacuum pump. Because the chamber has a transparent lid, it also allows for easy inspection of cleanliness or other physical issues.

The air monitoring subsystem allows for the monitoring of temperature, humidity and particle concentration within the livestock shed. The air sampling system requires a continuous flow of air, which is achieved using a small fan within a straight-through vent from one side of the case to the other. Within the vent are two sensor modules, a temperature and humidity sensor, and a dust particle sensor. As with the gas monitoring subsystem, the vent is mainly transparent, allow-

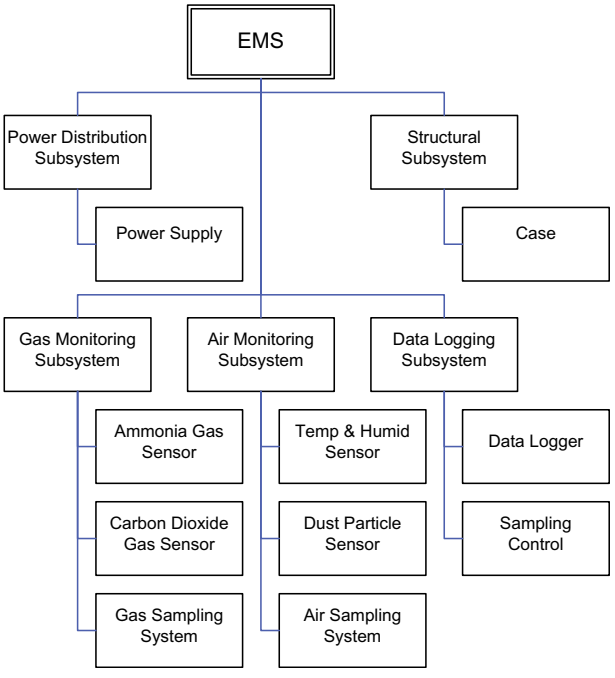

Fig. 1 – Physical architecture of the EMS (Clements et al., 2011).

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