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ScienceDirect

Physics Procedia 90 (2017) 271 – 278

Physics Procedia

Conference on the Application of Accelerators in Research and Industry, CAARI 2016, 30 October – 4 November 2016, Ft. Worth, TX, USA

A Distributed Data Acquisition System for the Sensor Network of the TAWARA_RTM Project

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Abstract

This paper describes a distributed Data Acquisition System (DAQ) developed for the TAWARA_RTM project (TAp WAter RAdioactivity Real Time Monitor). The aim is detecting the presence of radioactive contaminants in drinking water; in order to prevent deliberate or accidental threats. Employing a set of detectors, it is possible to detect alpha, beta and gamma radiations, from emitters dissolved in water. The Sensor Network (SN) consists of several heterogeneous nodes controlled by a centralized server. The SN cyber-security is guaranteed in order to protect it from external intrusions and malicious acts. The nodes were installed in different locations, along the water treatment processes, in the waterworks plant supplying the aqueduct of Warsaw, Poland. Embedded computers control the simpler nodes, and are directly connected to the SN. Local-PCs (LPCs) control the more complex nodes that consist signal digitizers acquiring data from several detectors. The DAQ in the LPC is split in several processes communicating with sockets in a local sub-network. Each process is dedicated to a very simple task (e.g. data acquisition, data analysis, hydraulics management) in order to have a flexible and fault-tolerant system. The main SN and the local DAQ networks are separated by data routers to ensure the cyber-security.

Peer-review under responsibility of the Scientific Committee of the Conference on the Application of Accelerators in Research and Industry

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Peer-review under responsibility of the Scientific Committee of the Conference on the Application of Accelerators in Research and Industry
doi:10.1016/j.phpro.2017.09.008

Keywords: water safety; distributed systems; data acquisition; real-time monitor; online analysis.

1. Introduction

Safe tap water is of paramount importance in our modern society. Recently, water plants have become sensitive sites that have to be protected against terroristic attacks or accidental disasters. Among the potential threats that can target the distribution of drinking water, there is the radiological contamination. Such contamination could be deliberate, in the case of a terroristic attack, or accidental, in the case of accidents in nuclear power plants or waste disposal sites. The demand for fast and reliable methods for tap water monitoring has been increasing. The aim of the TAWARA_RTM project is controlling the quality of drinking water, in terms of radiological contamination. The presence of radioactive contaminants in drinking water is monitored and recorded in real-time; in order to prevent deliberate or accidental threats. In this context, the goal of the TAWARA Real Time Monitor (RTM) system is the measurement of the gross alpha/beta activity using scintillation detectors submerged in the water. The platform developed for the project provides real-time measurements, data storage and interfaces with the water plants infrastructures. The TAWARA_RTM prototype was installed at the Northern Water Treatment Plant of the Warsaw Waterworks Company (MPWiK).

Liquid Scintillation Counting (LSC) has been a technique widely used in environmental applications (Forte *et al.*, 2002). Water samples are mixed with scintillators and the resulting cocktails are very effective in determining gross beta and alpha activity as well as in deriving spectral information. On the other hand, this is an off-line technique, as the samples have to be carried to laboratories for preparation and analysis. Several hours could pass between the sample collection and the actual measurements. Moreover, the treated samples have to be properly disposed of. For all these reasons LSC is not suitable for a real-time monitoring apparatus. Plastic scintillators have also been investigated as an alternative (Ifergana *et. al.*, 2015), for detecting beta particles in liquid samples. Another explored possibility is to use a sandwich type scintillation detector, made up of a layer of ZnS(Ag) and a plastic detector to collect alpha and beta counts at the same time (Ifergana *et. al.*, 2015). Advantages of these methods are the easier experimental set-up and maintenance. However, it is harder to distinguish between alpha and beta signals due to a higher background.

As part of TAWARA_RTM project commercial plastic scintillators were employed for the measurement of the radioactivity in water (Bodewits *et al.*, 2016). We selected the EJ-444 (eljentechnology.com) scintillator that is composed by a thin layer of ZnS(Ag) phosphors on a fast plastic scintillator. Alpha particles are detected in the ZnS(Ag) layer, whereas beta are detected inside the plastic layer. The difference in the decay times of the two scintillation signals allows the separation the two types of particles by Pulse Shape Discrimination (PSD).

2. The TAWARA_RTM platform concept

The TAWARA_RTM platform is installed along the normal treatment of the tap water, in the waterworks plant supplying the aqueduct of Warsaw, Poland, as shown on Fig. 1. At the raw water intake an Early Alarm Detector (EAD) monitors the water at the very first stage of treatment. It is meant to generate an alarm in the case of a sudden and large contamination with water containing gamma-radiation sources. With this early monitoring, the whole water treatment plant can be quickly stopped in order to avoid a severe contamination of the equipment. Several time-spans of analysis are foreseen (see section 6) for progressively smaller contamination events over larger time scales. After the ordinary water treatment, a Real-Time Monitor (RTM) is installed for smaller contaminations that were not filtered by the treatment nor detected by the EAD. The RTM is able to precisely measure both alpha and beta-emitting contaminants to monitor the public tap water safety. As for the EAD, several time-spans of analysis are foreseen. In the case of an alarm, samples of the water can be analyzed with a higher resolution spectroscopic system. All the information produced by the infrastructure is continuously stored in the local databases of the nodes and in a central database. The information is presented also to the waterworks operators; who are trained to handle the possible scenarios and emergencies and communicate with the civil security authorities.