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Towards Process Oriented Environmental Monitoring Systems for Intelligent Risk Management

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Abstract: Water monitoring and associated risk management requires a large number of in-situ monitoring stations. These stations measure water parameters and relay the measurements to a data centre. From a data processing point of view, such systems constitute distributed processing networks. In present water monitoring systems and in a wide range of other environmental monitoring systems the network aspect stops at the node or in-situ monitoring station (IMS) level. This paper extends the networking idea from the system to the IMS design level. We model an in-situ monitoring station as a network of communicating sequential processes. For this network we establish the fundamental system properties such as: security, stability and functionality. In a second step we translate this functional model into an implementation model with the same properties. The designer has the freedom to translate particular network processes into either hardware or software components. These components communicate over well defined interfaces which ensure composability. In the practical part we follow the two step design approach to integrate a new sensor into an existing IMS. First we create a process network with the desired properties. Then this process network is translated into hardware and software components for a hybrid processor. Finally, the functionality of the resulting component network is tested.

The process oriented design approach leads to more: secure, reliable, and functional systems. Furthermore, this design method simplifies the integration of In-Situ Monitoring stations into the water risk management system, because the complete system functionality is designed according to networking principles. This uniform network structure can be extended by feedback structures which mimic intelligent behaviour.

1 INTRODUCTION

Clean drinking water is one of the most important, if not the most important food for humans and animals alike. Furthermore, according to Gunatilaka [2006], it is in constant danger of being polluted by environmental threats. This is the reason why 9 institutions from 6 European countries formed a consortium to carry out the WARMER (WAter Risk Management in EuRope) project. The driving idea behind WARMER is to provide an intelligent water risk management system. Such intelligent systems have been identified by Sànchez-Marrè et al. [2006] as a future direction for environmental monitoring systems. They argue that only decision making systems can tackle the complex problems posed by environmental pollution and habitat destruction. According to Haykin [1994] all intelligent systems are feedback structures which are conveniently described as networks. Therefore, the network aspect plays an important role in the design of intelligent decision making systems. For example, Smiatek [2006] proposes environmental modelling in an event-driven multitasking network environment. He argues that such a network is the solution to the problem of linking data which is stored in different locations. This particular network based solution provides the means to create and deploy multitasking applications. The WARMER system can be described as a network of independent in-situ monitoring stations (IMS) and remote

sensing satellites, which measure environmental parameters. The acquired data is sent to a data centre where it is processed and stored. Furthermore, the data centre grants independent user applications access to the data.

From a data processing point of view the WARMER system and indeed most remote sensing systems are distributed processing networks. Unfortunately, in current water monitoring systems, and in a wide range of other environmental monitoring systems, the networking aspect stops at this abstract system level. That means, the underlying structure of individual entities is not designed and described in terms of networked components. This is a problem, because this inconsistency constitutes a break in the system design flow. Such breaks are undesirable because they make it hard to understand the underlying principles. These underlying principles are very important for the design of intelligent risk management systems. Apart from this philosophical or knowledge sharing problem, the break in the design flow leads, in many cases, to underperforming systems. Such systems tend to underutilise the available resources of distributed processing systems.

In this paper we propose extend the networking idea from the system to the node design level. This will increase flexibility and performance of the resulting environmental monitoring systems. Furthermore, this overarching system concept makes it possible to reason about security, stability and functionality of the complete system. These properties are the fundamental requirements for intelligent decision making systems, because such systems are designed as networked components which work cooperatively on the decision making task. To achieve the goal of extending the network aspect from the system to the design level we adopt the theory of communicating sequential processes (CSP).

The body of the paper consists of the following sections:

- **In-Situ Processing Platform Present and, Future** – Before we propose a new processing platform for the IMS it is necessary to evaluate the existing systems in terms of storage and communications.
- **Proposed Design** – This section discusses the attempts to meet these diverse and sometimes conflicting requirements.
- **Software Framework Implementation** – A vital aspect of the proposed system is the duality between hardware and software. In the following we discuss how we plan to implement the software system executed by machine architecture.
- **Example: Sensor Integration** – This section demonstrates the proposed CSP based system design flow.
- **Conclusions** – This paper makes the case for process oriented environmental monitoring system design.

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