Conceptual Modeling for Environmental Monitoring Systems

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Abstract. Environmental Information System (EIS) development is a complex task involving modeling several aspects of the physical real world and complexity management. Conceptual modeling is an essential premise for a correct development of complex information systems. Reusable conceptual schemas have the potential to facilitate this difficult and time-consuming activity. In addition, linking conceptual schemas to reusable software components may provide a way for reusing not only concepts but also software applications. We propose a conceptual model for the development of Component-based Environmental Monitoring Systems studying in a high-level analysis, the appropriate components and conceptual models for them

1 Introduction

An EIS [4] is a system for capturing, storing, checking, manipulating, analyzing and displaying spatio-temporal data relating to the environment and where the spatial coordinates are referenced to the earth [5]. Environmental problems are characterized by the complexity of the underlying processes [4], present in them due to many reasons. Systems with requirements such as integration facilities, complexity management, spacio-temporal scales, etc. must be developed over the basis of flexible and reusable models.

Conceptual modeling performs the key role during the development of EISs. Models provide abstractions of a physical system that help us to understand complex, real-world problems. Component-based systems adhere to the principle of divide and conquer for managing complexity. In the component approach, the primary emphasis is placed during architecture and design of the dependencies between the components and the management of those dependencies [2].

In this paper we propose a generic conceptual model using components of high-level of abstraction for a particular case of EISs, which are the environmental monitoring systems (EMSs). They are used associated with automatic monitoring equipment or remote sensing instruments. It's important to emphasize that they involve more than simply accessing and gathering data. During the data analysis phase, information processing must be applied to the data using complex statistical methods, simulation models, etc. in order to provide decision-making support. A conceptual model for EMSs must present the flexibility to bring such facilities in independent units of composition.

This paper is organized as follows: In section 2, the basic concepts of conceptual modeling are analyzed. In Section 3 conceptual models for an Environmental Monitoring System are proposed and Section 4 presents conclusions.

2 Conceptual Modeling for EMS Development.

The conceptual model captures real-world concepts and the associations between these concepts. This is an analysis-level activity (and not an attempt to design the actual software), achieving advantages such as simplicity, flexibility and reuse [9].

Component-based software development (CBSD) is based on the concept of composing or assembling systems out of independent but pluggable parts [10]. A conceptual component is a model/schema to be reused.

A package in UML, is a general-purpose mechanism for organizing elements into a group. Unlike Components, a package is purely conceptual [1]. During conceptual modeling, we can use them as subsystems to represent high-level components.

2.1 A EMS Conceptual Model

The Conceptual Architecture identifies the high-level components of the system, and the relationships among them [7]. We propose that an EMS must be considered as an assembling of separate concepts, which may be developed in different layers (Fig.1).

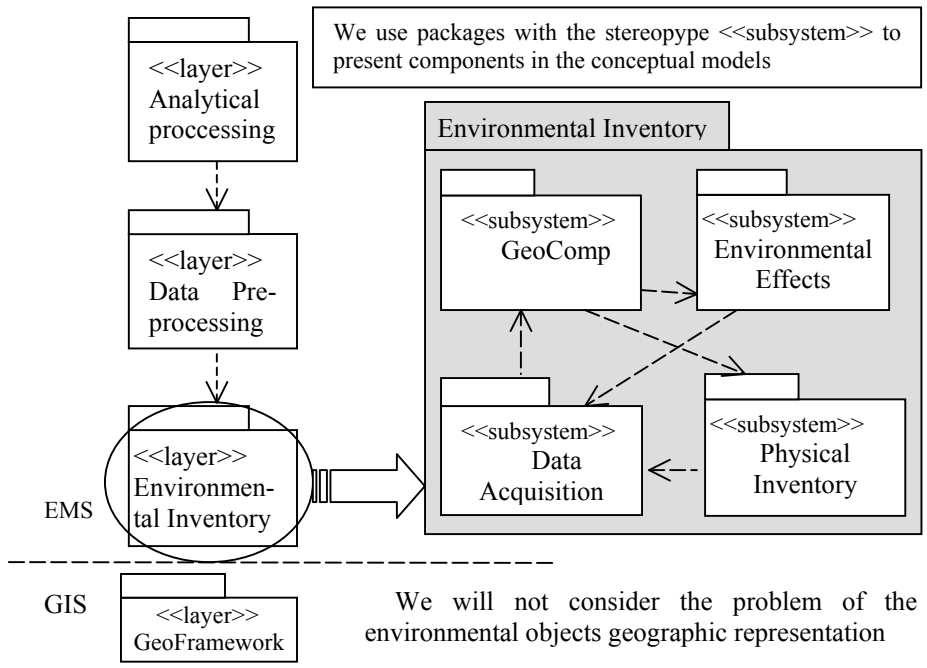

Fig. 1. Conceptual Architectural for Environmental Monitoring Systems: Layered architectural style to structurally organize an EMS.

2.1 Conceptual models for Environmental Inventory Components

The results of investigation and recognition of domain concepts and phenomena is described in application domain terms. The resulting model represents concepts and phenomena of the problem domain and their relationships. We studied existing software and conceptual models, looking for their optimal high level assembling. From a conceptual perspective, we draw a diagram representing the domain concepts for each component without worrying about implementation details (See Fig. 2,3,4,5).

We use conceptual class diagrams to show the structural model of each component.

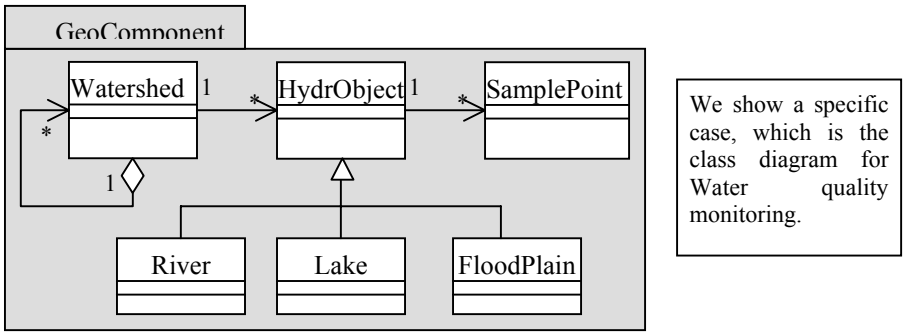

Fig. 2. GeoComponent: Defines the appropriate relationships and hierarchies that will be used for the environmental objects to be monitored.

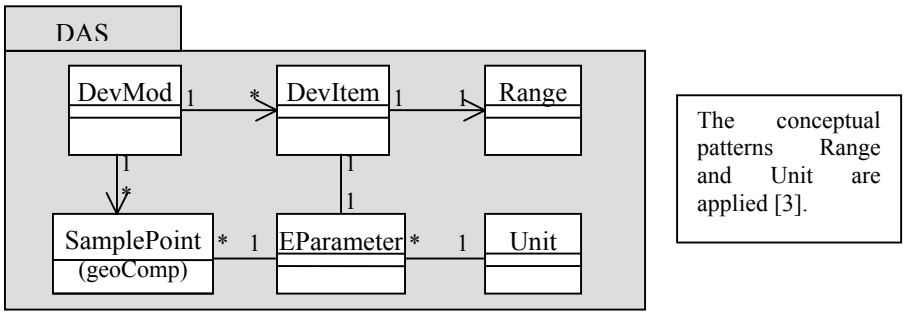

Fig. 3. Data Acquisition: The basis for building monitoring tools based on the use of remote devices. For a more detailed conceptual model of a generic DAS, see [8].

For the modeling of the Physical Inventory Component (See Fig. 4)*, Measurements and Observations* analysis pattern [3] is applied using an Observation type, which acts as a superclass of a measurement and a qualitative observation.

Many statements about environmental observations are made up using a diagnosis process, infiryng environmental effects through the parametrric observations. To record such observed environmental problems, we adapted the *Associated Observation* pattern [3] as it can be seen in Fig.5. This pattern may be used to record the evidence observation plus the knowledge used for diagnosis. The model presents two levels: knowledge level describes the possible evidence chains while in the operational level there are recorded the possible links.

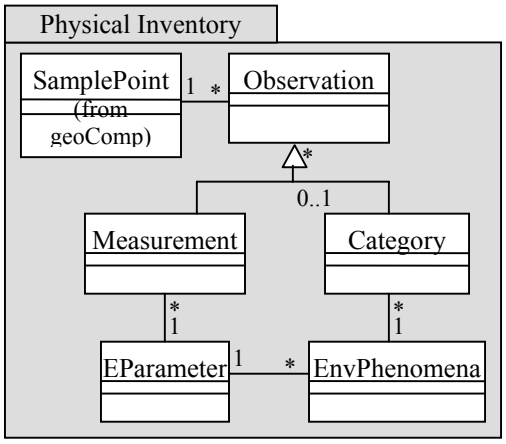

Fig. 4. Physical Inventory. Based on existing models, which have been developed applying analysis patterns [3][6][11]

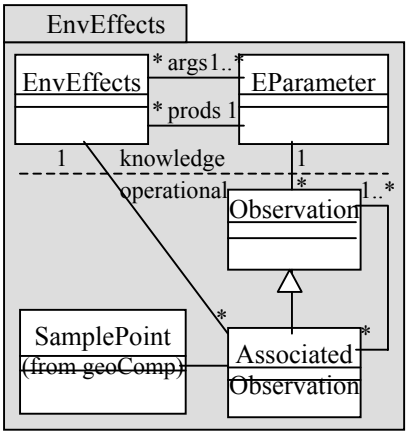

Fig. 5. Environmental effects: Manages the relations between physical measurements and observations and the environmental effects.

3 Conclusions

In this paper we propose a conceptual model for Environmental Monitoring Systems, based on the analysis of domain concepts. This model gives developers a high-level abstraction structural design for a generic EMS. We define a conceptual layered architecture for EMS. We identify different conceptual components for EMS as independent units, with the purpose of incrementing flexibility and reuse.
In future works we will formally specify component interfaces and interactions.

4 References

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