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From proprietary Environmental Software Systems to Interoperable Components

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Abstract: Rising awareness of the importance and vulnerability of the environment within the EU have led to several water related directives that culminated in the EU Water Framework Directive (WFD) on 23 October 2000 [1]. Politically a revolution, the WFD has so far mainly concentrated on legislative issues and unified reporting, but leaving the question of sharing the measurements and services between monitoring networks (across country and/or administrative boarders) to a later (implementation) phase. In the meantime, the INSPIRE (Infrastructure for spatial information in Europe) and GMES (Global monitoring for environment and security) initiatives are pursuing a technically even more ambitious agenda that will eventually lead to effective merging of all the environmental monitoring networks. In this paper, the present main achievements of the WFD so far are presented. It is explained why unified reporting is not the end of the road and the resulting ICT challenges are discussed. Additionally, the architectural approach and the resulting infrastructure developed in the ORCHESTRA Integrated Project is presented.

***Keywords**: interoperability, environmental information systems, open architecture, risk management*

1. INTRODUCTION – WFD

The Water Framework Directive (WFD) is widely recognized as one of the most ambitious and comprehensive pieces of European environmental legislation to date (European Commission [2000]). Its aim is to ensure that all European waters are protected according to a common standard.

The WFD has two key components:

- a system of management of the natural water environment based on natural river basin districts (instead of administrative and political regions); and
- the introduction of coordinated "programs of measures" with the ultimate objective of achieving (at least) "good status" for most of the European rivers, coastal waters and underground waters by 2015.

River basin management according to the WFD is a multi-step process. The first step, having been concluded by 2004, is to assess the ecological status of rivers, lakes and groundwater in each river basin district. For groundwater, the key factors are chemical contamination and water quantity, for surface water it is the quality of the structure and functioning of aquatic ecosystems as well as the chemical surface water status as a measure of pollution (Bazzani et al, [2005] and Vanrolleghem et al [2004]). The results of this phase are to be assembled at river basin level and then reported to the European Union.

1.1 Status and current situation

According to Marent [2005] the formal transposition into national law has been achieved by the member states and according to Art. 3 competent authorities for the implementation and reporting have been identified during 2004. Up to the end of 2005 approx. 195 European River Basins have been identified and an economic and environmental analysis (Art. 4) has been performed.
Currently it is heavily recognized by Member States, the European Commission, the EEA and other bodies with a stake in reporting procedures that there is a need for “streamlining” the reporting process, gathering more useful and relevant information and making the reporting process as efficient as possible using modern technology (i.e. Web based reporting).

The different EC organizations i.e. DG ENV, ESTAT, JRC and EEA together with the Member States have agreed on the development of a new comprehensive and shared European data and information management system for water - WISE.

WISE presents itself at the moment as a portal to facilitate the upload of WFD-related reports. One of the major requirements of the WFD to make information more accessible and interoperable by all data users is up to now not reasonably addressed. At the moment it is a straightforward bottom-up solution for reporting of water quality information – which is for the moment a simple practical solution.

According to the WFD implementation time table monitoring programs shall become operational during 2006 and 2007. That means that objectives will be set for each water body and respective river basin management plans will be put in place to achieve these objectives by 2009. The water body status will then be re-assessed to determine whether the specified objective has been met. This process will be repeated on a regular basis.

1.2 ICT challenges

The WFD is not only a fundamental rethink of the EU water policy, its implementation is also a challenge for the supporting information technology (IT) and, especially, for a WFD-specific information management. As already addressed above, in the first reporting phase of the WFD, there was and is still a huge need for harmonisation and possibly standardisation to achieve an efficient implementation of the WFD within Europe.

The need is even higher when considering that the WFD reporting obligations have also to be fulfilled by the new EU members or future member states whose environmental information infrastructure may have to be built from scratch with limited financial resources. Having this in mind, the European Commission has set up a WFD Common Implementation Strategy. In this context, a series of mostly thematic working groups and joint activities have been launched to support the development and testing of coherent WFD methodologies.

From the IT point of view, the working group Geographical Information System (GIS) is the most relevant one as it goes far beyond the implementation of just the geographical elements of the WFD. The specification elements of the current GIS Guidance document are listed in Vogt [2002]. One aspect therein, putting a real challenge on the European ICT world, is that due to the reporting requirement of the WFD, collaboration between authorities managing a river basin will turn the focus heavily on the requirement of interoperable systems.

Take a minute to think about the management of larger catchments like the Danube River Basin (DRB) and what it means for IT. For example the Danube River Basin District comprises 18 states, 13 convention member states, a catchment area of about 807.000 km2, a population of approximately 81 Mio. and 17 official languages and last but not least all the fascinating information islands operated by dozens of responsible authorities.

At the moment the GIS working group mainly considers the geo-data aspects, especially its data exchange and data access requirements. This is too focused and not sufficient in the long run as the above Danube example shows. There is a need for a more generic IT Framework Architecture that integrates the following views within a single concept:

- an organizational view that considers a cross-boundary information flow, i.e. across regional, national and organizational boundaries,
- a process view that considers the life cycle of the information involved including the fact that information (source) systems will change over time,
- a data view that integrates both geo-data, tabular and textual data, thematic documents and meta-data, and
- a functional view that considers what generic and specific functions (services) are required on which level as well as their signatures and access methods across networks.

The main characteristics of these views are highlighted in Usländer [2005].

The cross-boundary aspects of information exchange as well as the requirements stemming from the several views listed above are not purely WFD-specific. There exist many other environmental domains like risk or crises management dealing with similar problems. Whenever environmental crises occur, the will never respect any boundaries – neither organizational nor country ones.

An example how to cope with this challenges in the future is the development of an open service oriented architecture allowing interoperability between existing systems (regardless its domain) or yet unknown upcoming information systems.

2. THE ORCHESTRA PROJECT

The cross-boundary respectively cross-system issues developed in the previous section and further more addressed by Denzer et al [2005] are present in many application domains of environmental and risk management. Risk management itself is a major strategic objective of the 6th framework program of the EU and general purpose infrastructures for supporting information management are a key necessity to solve risk management problems, which are complex and cross-boundary in nature.

The term Risk Management here is intended to encompass all the activities relating to the management of hazards, vulnerabilities and consequences over a territory over time. The Risk Management cycle groups these activities into the following sequential phases: prevention and mitigation of hazards appearing on the territory; preparation for the imminent occurrence of a hazardous event; response to the impact of the event (emergency situation) and finally reconstruction to restore the functionality of the territory. Within each of these phases the different activities are usually supported by different methods and tools used by specific stakeholders and specialized by the respective risk domains (like fire, flood, seismic, coastal zone & technological).

any given phase of the Risk Management cycle, Decision Makers and Stakeholders do not have easy access to the information that they need in order to fulfill their goals. For example, a typical question that is often posed is “what are the risks that exist on my territory”. The response to this question is dependent on the phase of the Risk Management cycle where the question is being posed and who is posing the question. Currently, no single integrated system exists that can fulfill this request, and information produced in each phase is often incompatible.

ORCHESTRA aims at tackling this problem through the definition of an Open Service Architecture that will go a long way to improving this situation by providing a platform for harmonizing the production, interoperability and consumption of Risk Management related information. With ORCHESTRA, actors will be able to capitalize on previous experience through the discovery of information resulting from analysis conducted in previous phases by other stakeholders.

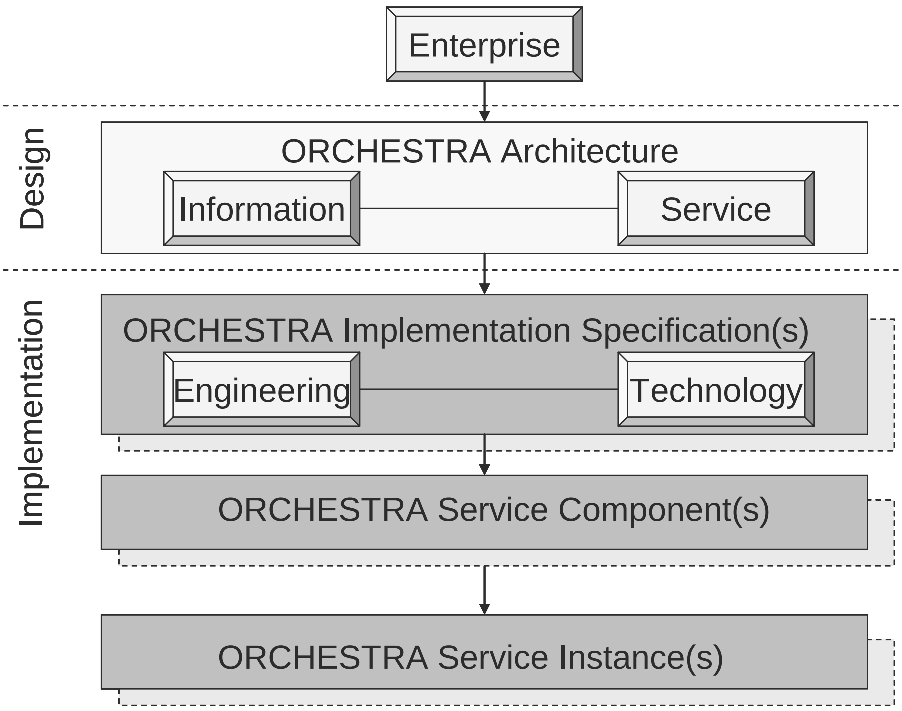

Figure 1: ORCHESTRA Reference Model, RM-OA [2005]

Moreover, results from earlier phases are often re-used in later phases, i.e. results from consequence/simulation models can be reused during emergency response. Therefore, the main problem today is that in any given activity and in

2.1 ORCHESTRA’s architectural process

The architectural process of ORCHESTRA is based on the principles of the following international standards:

- The Reference Model for Open Distributed Processing (ISO/IEC 10746 RM-ODP) is used for the structuring of ideas and documentation.
- The OpenGIS Service Architecture (especially ISO/DIS 19119) is used for the taxonomy of the ORCHESTRA services.

RM-ODP is an international standard for creating open, distributed processing systems. It provides an overall conceptual framework for building distributed systems in an incremental manner. The ORCHESTRA architectural process uses the RM-ODP viewpoints for the structuring of ideas and their documentation. The mapping of the viewpoints to ORCHESTRA is indicated in Schimak et al [2005]. As the Orchestra deployment will have the nature of a loosely-coupled distributed system based on operational services rather than a distributed application based on computational objects, in ORCHESTRA the "computational viewpoint" is referred to as the "service viewpoint".

The ORCHESTRA Reference Model covers all five viewpoints in the following manner:

- The analysis phase is described as part of the Enterprise Viewpoint.
- The design phase encompasses the harmonized specification of the Information and Service viewpoint resulting from requirements of the Enterprise viewpoint. The result is the ORCHESTRA architecture that is, by definition, a platform-neutral specification according to the requirements of ISO/DIS 19119 (i.e. specification in UML).
- The ORCHESTRA architecture does not cover the Engineering and Technology viewpoints.

The aspects of the Engineering and Technology viewpoints are combined in one or more process steps. Each step represents one mapping to a specific service infrastructure (e.g. W3C Web Services) and leads to a platform-specific ORCHESTRA Implementation Specification.

The ORCHESTRA Reference Model (Figure 1) comprises a specification framework of all RM-ODP viewpoints for the open architecture for risk management. In particular, it encompasses a framework for the specification of the ORCHESTRA Architecture and a framework for ORCHESTRA Implementation Specifications implemented in ORCHESTRA Service Components and deployed in an ORCHESTRA Service Network (OSN) as ORCHESTRA Service Instances (OSI). In ORCHESTRA a two-step approach is pursued.

The first step focuses on the specification of the Architecture in a way that the ORCHESTRA Architecture (OA), based on the ORCHESTRA Reference Model, comprises the combined generic and platform-neutral specification of the information and service viewpoint. This generic approach ensures that the OA is well-suited for a long lifetime. Moreover, the asset of providing such a generic framework is that the OA does not have to be constantly adopted. Furthermore the specified architectural framework becomes suitable for many other business models, not necessarily environmental or risk management-related domains.

The second essential step is to define the domain relevant (meta-/) information models or in other words to specify application schemata and to identify what hardware/software/platform components are needed and/or involved. This process is called the ORCHESTRA Implementation Specification. Thus, an ORCHESTRA Implementation Specification comprises the combined platform-specific specification of the engineering and technology viewpoints as a result of the mapping of the ORCHESTRA Architecture to a specific service infrastructure (e.g. W3C Web Services).

At the end of the specification and implementation procedure it is aimed to have numerous implementations of ORCHESTRA service specifications as so-called ORCHESTRA Service Components. As running ORCHESTRA Service Instances these are working together in so-called ORCHESTRA Service Networks, i.e. at the end of the day ORCHESTRA (domain) specific networks. will have to be created. Such ORCHESTRA Service Networks will not only offer generic functionality but also domain-specific services (so-called thematic services) and information. The RM-OA provides the architectural framework and specifies rules in order to design such.

Next interesting aspect of the OA is the idea of the ORCHESTRA Application Architecture (OAA) shown in Figure 2, and defined in the RM-OA as "an instantiation of the ORCHESTRA Architecture by inclusion of thematic aspects stemming from a particular application domain" (e.g. a risk management application). Consequently, ORCHESTRA Applications can be implemented by re-using the software components/services already present within OSN, rather than built from a scratch in a monolithic way. Therefore an ORCHESTRA Application as a set of software components that together comprise an application based on the usage of ORCHESTRA Services.

- an OT Service provides an application domain-specific functionality built on top and by usage of OA Services and/or other OT services.

OA Services are further classified into two sub-

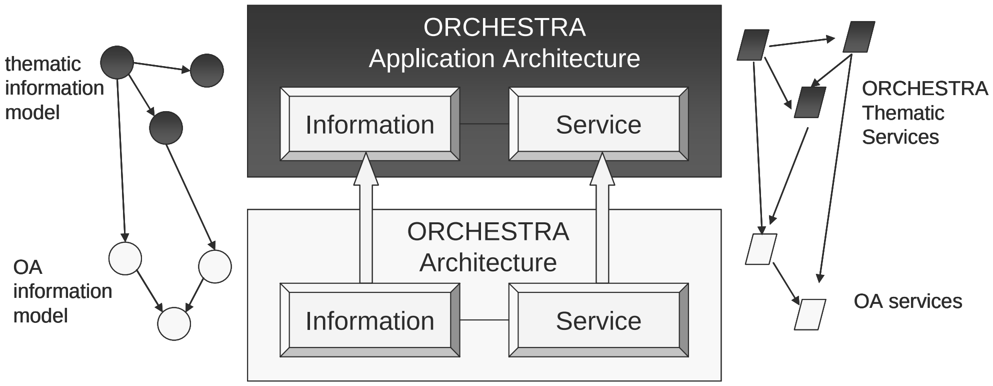

Figure 2: ORCHESTRA Application Architecture (OAA), RM-OA [2005]

categories:

- OA Info-Structure Service: These are OA Services that are required to operate an OSN in the sense that these services play an indispensable role in the operation of an OSN. Representatives are Feature Access Services (for maps, documents, source systems), Catalogue Service(s), (service) Monitoring Services, Control services (like User Management Services, Authorization Services, Authentication Services).

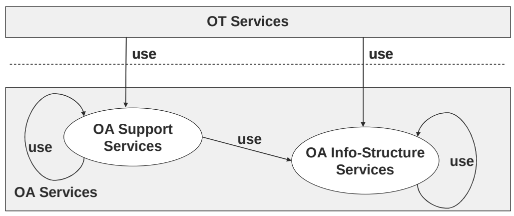

Figure 3: OA-service structure, RM-OA [2005]

- OA Support Service: These are OA Services that facilitate the operation of an OSN, e.g. providing an added-value by combining the usage of OA Info-Structure Services. Representatives are services for facilitating semantic queries like query mediation, inferencing, annotation and ontology access services.

Both together comprise the generic information infrastructure (info-structure) of the RM-OA. The OA Services thus provide the functional basis for application domain-specific functionality. This functional classification is illustrated in Figure 3.

2.2 ORCHESTRA services – main requisite of an ORCHESTRA service network

The Service Viewpoint (Figure 1) of the RM-OA specifies the ORCHESTRA Services that support the syntactical and semantic interoperability between source systems and between services and the development of ORCHESTRA Applications. This includes the management of an ORCHESTRA Service Network (OSN) as one particular application, too. In combination with the specification of the ORCHESTRA Information Viewpoint, their specification provides the ORCHESTRA Architecture.

According to RM-OA principles, ORCHESTRA Services includes all properties of services that may be specified in a platform-neutral way. Their mapping to infrastructure platforms (like e.g. a W3C Web Services environment) is being specified as part of an ORCHESTRA Implementation Specification.

ORCHESTRA Services are services offered by an ORCHESTRA Service Network whereas a service is a collection of operations, accessible through an interface, that allows a requestor of the service to evoke a behaviour of value to him.

ORCHESTRA Services are functionally classified in service categories. The main service categories are ORCHESTRA Architecture Services (OA Services) and ORCHESTRA Thematic Services (OT Services). In principle:

- an OA Service provides a generic, platform-neutral and application-domain independent functionality and

3. CONCLUSION

Good News: The problems of non-interoperable environmental information systems may be overcome. If information system developers agree to develop according to the ORCHESTRA Reference Model, define their Application Schemata and services according the recipes of the ORCHESTRA cook book (rules in the RM-OA) they are guaranteed that they produce interoperable information systems capable to cross boundaries in the discussed sense. This will be very important when realizing the expected paradigm change in the implementation of the European Water Framework Directive from a push-oriented reporting schema towards a pull-oriented information sharing based on a service-oriented architecture. But it goes far beyond that. Appling ORCHESTRA (standard) assures designing robust and scalable systems as well as staying independent from system dynamics (i.e. when underlying integrated information systems structurally and semantically change over time).

However, even with support of standardization organizations (like OGC) it will still be a long way to get all political support needed for the EU-wide deployment of ORCHESTRA Service Networks as well as raising the awareness and acceptance by the IT world.

4. ACKNOWLEDGMENTS

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5. REFERENCES

Bazzani, G. M., Di Pasquale, S., Gallerani, V., Morganti, S., Raggi, M., D. Viaggi, D. The sustainability of irrigated agricultural systems under the Water Framework Directive: first results. Environmental Modelling & Software, Volume 20, Issue 2, Pages 165-175, 2005

Denzer, R., Güttler R.; Schimak G., Usländer Th., Atkinson M. ORCHESTRA – Development of an Open Architecture for Risk Management in Europe. International Symposium on Environmental Software Systems (ISESS 2005) Sesimbra, Portugal, http://www.isess.org/, May, 2005

European Commission. Directive of the European Parliament and of the Council 2000/60/EC establishing a Framework for Community Action in the Field of Water Policy. 1997/0067(COD) C5-0347/2000 LEX 224., 2000

Marent H. Overview presentation of the Water Framework Directive 2000/60/ EC – Implementation Process in Austria – Technical Aspects, ARCS Watermark Workshop Vienna, Nov. 17th, 2005

RM-OA 2005, Usländer, Th. (Ed.). RM-OA - Reference Model for the ORCHESTRA Architecture. Deliverable D3.2.2 of the ORCHESTRA Consortium, Version 1.10, Oct. 2005. Submitted to OGC as Discussion Paper 05-107, https://portal.opengeospatial. org/files/?artifact_id=12574.

Schimak G., Usländer Th., Denzer R., Pichler G. ORCHESTRA – Entwicklung einer offenen, service-orientierten Architektur für das Risikomanagement in Europa in GIS und Sicherheitsmanagement, Hrsg. Strobl/Roth, AGIT Symposium und Fachmesse für Angewandte Geoinformatik, Salzburg, Juli 2005, H. Wichmann Verlag, ISBN 3-87907-432-1, 2006

Vanrolleghem, P. A., Benedetti, L., Meirlaen, J. Modelling and real-time control of the integrated urban wastewater system. Environmental Modelling & Software, In Press, Corrected Proof, Available online July 29th, 2004

Vogt, J. (Ed.) 2002. Guidance Document on Implementing the GIS Elements of the WFD. Report of the Working Group GIS as part of the Water Framework Directive (WFD) Common Implementation Strategy. http://forum.europa.eu.int/Public/irc/env/wfd/home

Usländer, Th. 2005. Trend of environmental information systems in the context of the European Water Framework Directive in Environmental Modelling & Software, Volume 20, Number 12, Special Issue "Environmental Knowledge and Information Systems", Pages 1532-1542, 2005

Further important links

GMES	Global Monitoring for Environment and Security; http://www.gmes.info/
INSPIRE	Infrastructure for Spatial Information in Europe; http://www.ec-gis.org/e-esdi/
ISESS	International Symposium on Environmental Software Systems http://www.isess.org/
OGC	The Open Geospatial Consortium home page; http://www.opengeospatial.org