Water Quality Service for Lakes

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Abstract

Typical problems with environmental monitoring and research data are diverse data formats, archiving methods and lack of metadata. In past few years, standards to save and distribute data and metadata have started to emerge. Implementation of this common data management has been promoted by organizations and networks such as LTER-network, ALTER-Net, LifeWatch and GEOSS. The introduction of standardized metadata for data repositories in public sector and interfaces built on them, allows sustainable business opportunities also for the private sector. From this standpoint, Water Quality Service for Lakes -project develops a local database for environmental data providing standardized metadata and/or web service interface. Information sources for the database include traditional in situ measurements, automated monitoring platforms and remote sensing. All data will be tagged with XML-based metadata. Automated interpretation, combination and forecast tools that use this data bank are then deployed, as well as a web service interface for private service providers. A private IT-company develops the web-based Water Quality Service, which offers both free and chargeable environmental information for the local end users. The commercial side of the service provides water quality information that is specifically tailored to users' needs. The public side of the service publishes general environmental information and encourages citizens to participate with discussion forums and 'blogs'. This project aims to develop an operations model for an environmental monitoring service that combines the functionality of public and private sector, as well as several monitoring data sources. The model provides business opportunities for private sector as a service provider, as an end user, or as a data provider. At the same time it allows standardized organization of local environmental data which is highly valuable for research organizations. General goal is that this operations model can be copied to other monitoring regimes. Furthermore, the project develops a cheap 'layman's' device for measuring water quality, which is based on the cameras in mobile phones. This creates new business possibilities for e.g. mobile service solutions, which are as well developed in the project.

Keywords: Water quality monitoring, layman measurements, data management, public/private sector monitoring, interface, end user questionnaire

Introduction

Public organizations collect and store vast amount of environmental information. Depending on the organization, the elaborateness of the data varies. Public universities, for example, possess detailed data resulted from research and local monitoring, whereas national level organizations often keep up data sets relevant in larger scale contemplations. In many cases, however, standardized interfaces which can be used to access these public data sets are not developed. At least in Finland, this has hindered the development of business activity that takes advantage on the environmental information collected by the public sector.

In Water Quality Service -project we aim to develop feasible data interfaces between local and public sector. Pilot area is Lake Vesijärvi located in Southern Finland from which data is collected with various methods. These include manual sampling, automated and remote sensing measurements.

Based on these data sources, we will develop a local environmental database with Web service interface that can provide environmental data automatically on request with standardized methods. This database will be utilized by a local private company, which develops an internet based information and discussion service based on near real time environmental data. General idea is that the standardization of public sector databases allows the development of new business applications. One of the outcomes of the project is a documented operations model for the combination of the functionality of the public and private sectors. This documentation will identify the business opportunities within the public data sources and document an operations model for the utilization of this data.

The essential part of the project is the development of the Secchi3000 device for feasible layman water quality measurements. The device will take advantage of digital cameras in e.g. mobile phones. This allows the development of mobile services attached to the water quality estimates made with Secchi3000 devices.

Water Quality Service -project started in August 2009 and will continue until January 2012. The technical solutions in the project are developed in the co-operation between University of Helsinki, Finnish Environmental Institute, University of Jyväskylä and Aalto University School of Science and Technology**.** This paper presents the essential parts of the project including 1) a questionnaire survey aimed to identify the needs for the water quality data from the service point of view, 2) Data Management solutions based on a SQL database and Web service interface, 3) Mobiwater/Secchi3000 work package, where a new 'laymans' water quality measurement device and methods for mobile services are developed and finally 4) the business idea behind the Water Quality Service.

Questionnaire survey

A questionnaire survey was conducted to identify the information needs of potential end users of the Water Quality Service. Selected 8 potential end users were interviewed personally. They represented local energy and water companies, local and regional environmental administration, research, and local media. In addition, a web-based questionnaire was prepared, where slightly different questions were targeted to those who need lake data in their profession and to those who may need lake information in their free time. Questions concerned the type of information needed and its coverage in time and space. Interest towards chargeable services, discussion forums, blogs and for sending own lake observations to the Water Quality Service were also asked.

Invitation to fill a web-based questionnaire was send to a total of 310 e-mail addresses, part of which contained several recipients. Professional users included researches working in the universities, institutes or associations; local water, environment or fishing authorities; professional fishermen; private companies offering accommodation, leisure activities or ship travels on the lake; real estate agents; as well as teachers at elementary or university level. To reach non-professional lake users, such as household and recreational fishermen, boaters, sailors, canoeists, divers, surfers, voluntary lake rescuers and environmentally active citizens, e-mail addresses were collected from web pages of different hobby associations around the lake. Students of environmental science in Lahti were also invited. To reach citizens outside the mailing list, the questionnaire survey was advertised in a local newspaper and their web site.

A total of 155 persons filled the web-based questionnaire yielding 60 replies to the professional side and 109 replies to the recreational side. Most of the responded professionals worked in universities (27%) or in environmental administration (25%). Their information needs were wide. As many as 98% selected one or more options of general lake information, most important being a summary of lake monitoring and water quality. Similarly, 87% needed at least some information about services or actors around the lake. Physical and chemical water quality information was needed by 85%, most importantly, oxygen content, secchi depth, nutrients, pH and water temperature. Almost all (97%) respondents needed biological information. Data on fish, cyanobacteria and chlorophyll-*a* were needed most. Further, 85% of professional respondents needed information about ice cover or hydrology, most importantly, ice smelt and freezing dates, summertime water level and the quantity of the out flow. Watershed information was needed by 81%, especially the borders of the watershed, land use, and nutrient inflow. Lake depth information was important for 87% and weather data for 53% of professional respondents. In addition, 75% believed that Water Quality Service could benefit education.

As many as 65% of recreational users chose ‘the interest about the state of the lake’ as a reason why they needed lake information. The second popular reason was swimming (60%). Accordingly, a summary of lake monitoring and water quality interested most (77%) of general lake information. The most wanted information about lake services concerned beaches, recreation areas and camp-fire places (81%). Water quality parameters interested 93% of recreational users, most importantly, water temperature and transparency. As many as 89% of recreational users were interested in biological parameters, especially the microbiological quality of swimming water and the occurrence of cyanobacteria. The most needed hydrological or ice cover information was the thickness of the ice cover (88%). Watershed information was not so important for recreational users, but weather data was more important (78%) for them than for professionals.

Spatial and temporal needs for the information were different for professional and recreational users. While professionals needed information mostly from lake pelagic zone vertically in each depth, recreational users were more interested in shoreline. Time frame mostly needed by professionals was long, several years. Both groups were interested in water quality predictions (>70%).

The information was usually wanted as illustrative graphics or maps (Fig. 1), although professionals also wished various table formats. In both groups most respondents (98%) selected internet-based user interface as a best way to get lake information. Interest towards chargeable services was still cautious, however, as only few expressed their interest, and many replied, ‘don’t know’. There was interest towards chargeable web-based service among those who were personally interviewed, although many liked to see the product first. There was also interest to develop co-operation and information change as an alternative for direct payments.

Recreational users were highly interested in both discussion forums and blogs (85% and 72% respectively). The state of the lake was the most popular topic for discussion. Several respondents (61%) were also interested in sending own observations to the service, and in measuring water quality with layman’s device.

In all, there was a clear need for local lake information, both among professionals and recreational users. The recreational users were concerned about the state of the lake and they also had clear interest in active participation on the lake forum.

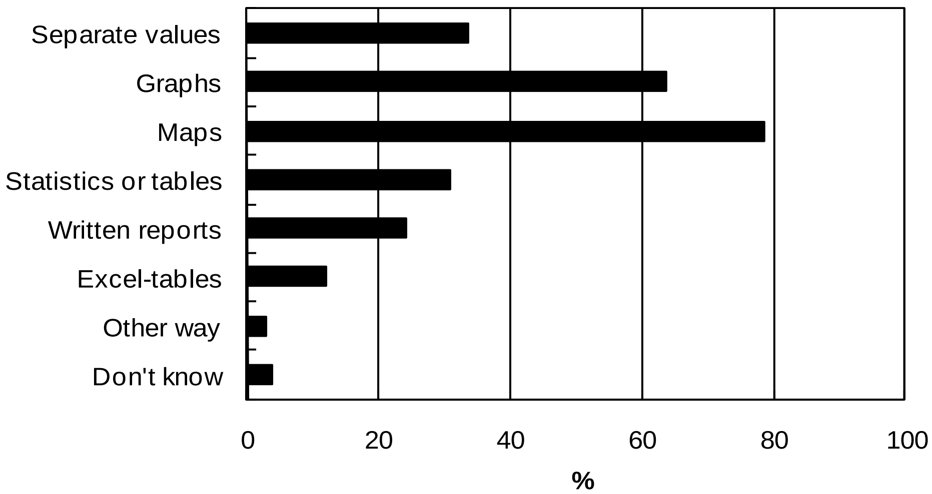

Figure 1. Recreational users wished lake information mostly as illustrative maps or graphs.

Database and interfaces

The monitoring and in situ data are stored in a SQL database. The structure of it is partly normalized, partly a data warehouse. The fact tables are for actual measurements and the dimension tables are for different dimension of place and time. For example a certain point of time represents also a certain hour, day, month and year. Dimension tables make the information retrieval efficient and quick.

The metadata of the data are stored in the SQL database. When retrieving the data via user interfaces, the metadata is produced in standardized format (e.g. using EML, Ecological Metadata Language). The documentation of data is stored together with original monitoring and in situ data.

Metadata itself and EML-files automatically produced together with search results are adequate for evaluating, comparing and exchange the data, but software and services built on the data need more efficient and automatic solutions. Water Quality Service for Lakes will offer a Web service interface for providing data on request (SOAP request-response model). Examples of fact, dimension and summary tables of the database are presented in the Figure 2.

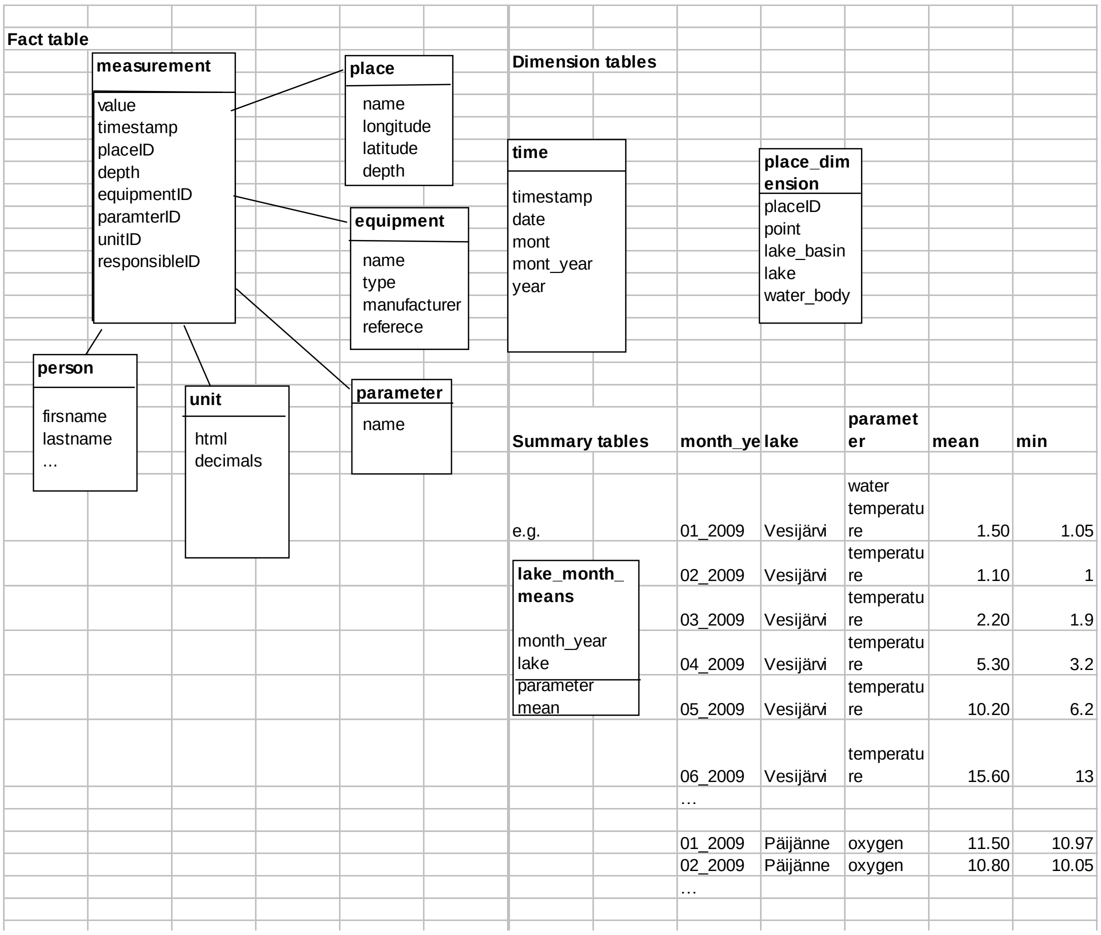

Figure 2. Examples of fact, dimension and summary tables of the database.

Mobiwater/Secchi 3000 development

Digital cameras are simple spectrometers that measure the light reflected by the target in three broad spectral bands (red, green and blue). Despite the technical limitations of commercial digital cameras (e.g., limited number of bands, broadness of bands, difficulties in calibration and so on) they have been successfully used to estimate water quality parameters such as coloured dissolved organic material (CDOM), Secchi Disk Depth (SDD), mineral suspended solids (MSS) and chlorophyll a (White et al. 2005, Goddijn and White 2005) in coastal waters.

The main advantages of using digital cameras are that they are cheap – especially when compared to professional spectrometers - and widely available (many mobile phones include a camera). Thus, by developing measurement methods that reduce the effects of the limitations of digital cameras it is possible to significantly expand the amount of in situ data measured from water bodies.

The development of the Secchi 3000 prototype device started in 2009. In the current test versions a number of white and black plates with known spectral characteristics are used to reduce the ambiguities of the camera measurement. The plates are at different depths and by analyzing the digital number (DN) value differences between the plates, the properties of the water column between the plates can be estimated.

The development of interpretation algorithms, which convert DN differences and/or band ratios into values of water quality parameters, involves Hydrolight (Mobley 1994) simulations of upwelling radiance. The test versions will be used in several campaigns during summer 2010 and the final prototype will be ready in fall 2010.

Water quality service

Water Quality Service will be provided by a private IT-company specialized in internet services. Water Quality Service will utilize the public interface to the database and offer both free and chargeable environmental information targeted especially to the local end users. The commercial side of the service will provide water quality information that is specifically tailored to the customers' needs. Potential customers for this commercial side include water and electricity companies with legislative obligations for environmental impact monitoring, media in different forms, real estate business, tourism, diving clubs and professional fishers. In addition, governmental and municipal institutes can find the cultivated and easily accessible environmental data useful. The public side of the service offers up to date environmental information and encourages citizens to participate with discussion forums and 'blogs'. Goal is to create a general information and discussion portal centered on the issues in the local environment. This portal is aimed specifically to the citizenry, cottagers, free time fishers, canoeist, and boaters, but also for the civic organizations and happenings. Revenue logic of the service will be based on the service fees, adds on the portal, mobile services and potentially also on the measurement device selling.

Conclusions

The main idea in the Water Quality Service –project is to develop an operations model for environmental monitoring that combines the interests of private and public sector. The model provides business opportunities in many levels. In addition to the service provision, which directly utilizes the public databases, business opportunities can also emerge based on the usage of the service and also for the companies that provide environmental data or devices. At the same time the standardized organization of local environmental data is valuable for the research and development in the public sector. The overall goal is therefore to create sustainable infrastructure that is found useful by actors both in public and private sector. The development of new measurement devices (Secchi3000) will allow citizens interested in environment to participate in the measurement of water quality and thus expand the amount of data that are collected in situ.

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