WISKI – A WORLD WIDE USED ENVIRONMENTAL MONITORING SYSTEM

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Abstract: WISKI 7 is the latest version of a, since now more than 20 years experienced information management system, that provides modern tools for advanced analysis of environmental monitoring data. It is based on the KISTERS Time Series Management core solution, which brings together solutions for all actual requirements of modern environmental monitoring with its quantitative and qualitative parameters. The modular system includes data acquisition, storage management, data analysis and computation, data exchange, data presentation including spatial projection, web publishing and alarm management.

Keywords: environmental monitoring, hydrology, water quality, air quality, information management systems, WISKI, TSM, GIS

INTRODUCTION

The management of water as natural resources is one of the central challenges of our generation, and how we act today has consequences for all future generations. System states and changes must be traceable, and decisions must be based on facts for future verifiability. The general task is to transfer the natural world and its dynamics into a world of data points which can be recalled, transferred, validated and stored in periodic intervals.

In many technical and commercial software systems, it is necessary to acquire process and archive mass data in the form of time series. In addition to many specialist technical aspects, rapid processing and quick data access are of the utmost importance. These demands call for specific software solutions, which up until now were typically developed independently for each application.

WISKI 7 INFORMATION MANAGEMENT SYSTEM

The Water Management Information System WISKI with its newest version 7 brings together solutions for all actual requirements of modern environmental monitoring, including data acquisition, storage management, data analysis and computation, data exchange, data presentation as a spatial projection or web publishing. WISKI presents a high-performance data management system with broad application flexibility and unlimited scalability combined with security and reliability, state-of-the-art technology and a future proof design. According to the robustness of monitoring system and its requirements for data acquisition and management there are various types of system architecture from simple basic up to complex, redundant system (Fig. 1).

MAIN CHARACTERISTICS

All data as metadata and time series data are stored in a structural relational database. The hierarchical system is based on station concept, which is the core of the WISKI 7 data structure. A station basically consists of a set of metadata that are type-specific and one or many parameters. Each parameter can hold one or more time series. The time series can be linked together with calculation methods. For example in case of the surface water station, is also used to determine the river flow (gauging station). The flow time series is derived from the continuous stage time series through a set of rating curves. The summary statistics for flow are derived from the continuous flow time series.

The core technology, which provides the backbone of key services for water management data processing is called KISTERS Time Series Management (KiTSM). KiTSM is combining interdisciplinary demands on time series processing with regard to mass data capabilities, scalability, modular design and flexibility to work in diverse specialist areas, high level of automation, reliability, security, integration potential, broad platform independence, redundancy and resilience.

Standard time series data structure contains time stamp, value, quality and interpolation type. Time interval of time series can be regular or flexible, with possibility to add time offset. Between two points is clearly defined the interpolation type, which could be changed over the time.

All calculations and auto validation routines comprise the organic part of execution system.

Data operations as algorithms, in WISKI terminology called Agents are operating on time series data and their main purpose is to either auto validate time series or derive other time series. Agents are generally triggered on data change events and executed automatically each time the data is accessed (such as by reports, graphs, exports, calculations); with KiTSM time series are also automatically updated in the background.

WISKI 7 as a client application is a strong, modern desktop tool connected to all metadata and time series data. The WISKI7 Explorer is the central window of the application. Key lists and basic data are organised in different hierarchies. Generally time series can be graphed by selecting the time series, setting the time range or displayed also in tables. Environment of graphical view allows providing various types of data corrections, arranging graphical layout and elements as well as print, copy or save the graph (Andjelic *et al.* 2010)

META DATA MANAGEMENT

Meta data are organized in hierarchical structure based on site-station-parameter concept. Site level could be customized as for example administration or geographical unit.

The requirements on Station Meta Data differ from customer to customer. WISKI7 is asked in various Implementation Projects to support regional and local standards. In the past the Meta Data System was extended with customer specific requirements. Because of the experience of more than 20 years in water industries and environmental monitoring, WISKI7 offers a very flexible and configurable Meta Data Management framework.

Set of metadata is configurable by administrators at configuration time. Standard Meta Data fields such as strings, numbers, dates, text fields and check boxes can be associated to any definable station type. More advanced metadata objects such as histories or even key lists can be flexible defined as Additional sta-

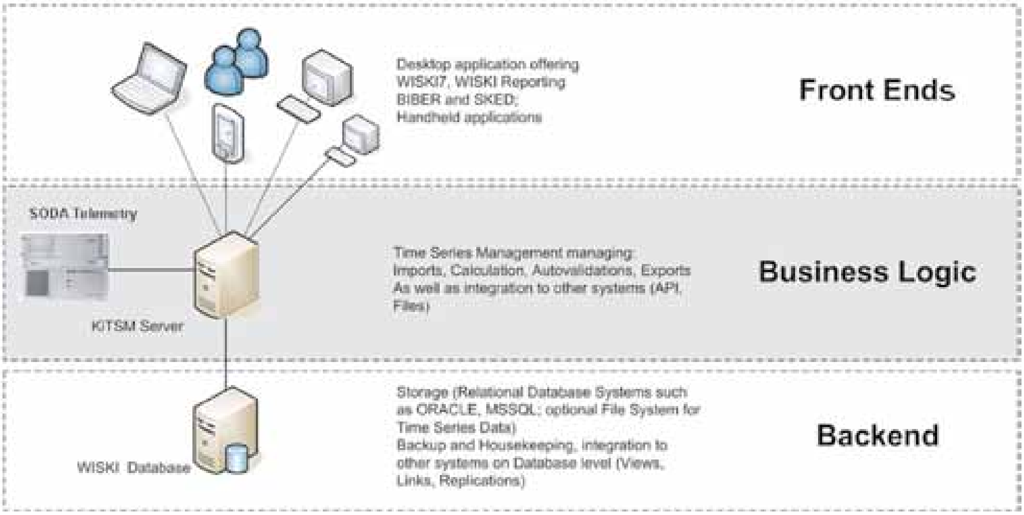

Fig. 1. Basic Architecture of WISKI solution

tion attributes. Metadata attributes are coupled to a station type/characteristic. A station can have multiple characteristics at the same time.

Precipitation, water level, flow, humidity, air temperature, water temperature, wind velocity, etc. are parameter types. Parameter type could be also technical parameters of equipment like e.g. battery voltage or in case of show caves number of visitors. Like other important definitions the parameter types are defined centrally.

KISTERS TSM (TIME SERIES MANAGEMENT)

The KISTERS TSM system is the new shared system core of all KISTERS products where time series are involved. It represents the business layer of a 3-layer architecture, and provides all services necessary for time series management and calculation to applications built upon it.

Data acquisition and integration

In order to support a more integrated approach to environmental data management, a modern monitoring information system has to acquire and store all types of data from a wide range of parameters. Not only the commonly used parameters such as water stage and discharge, but also, for example climate parameters to allow analysis within the same system.

Typical data input sources are remote data acquisition from field data loggers, import of third party data via input files in different formats, read out of field devices, digitisation from graphical charts or manual input using the interactive time series editor.

The import process should be automated as much as possible to free staff resources from manually entering data. The WISKI data acquisition server allows the automatic collection of data from field data loggers. The Import Server can scan directories and import data files, which are saved via the TSM layer into the database. When the user digitises graphical charts, the digitised data is imported automatically afterwards, without user intervention.

Data storage

Due to the complexity of data modelling, WISKI stores data in relational database systems (RDBMS). The storage of recorded or calculated time series data is managed by the central TSM. Additional station information available and other meta data are stored in a separate submodel. As historical data plays a fundamental role in environmental monitoring, one of the greatest challenges is to achieve a high level of performance when dealing with large amounts of measured data; this is a key objective of the developers. Another fundamental aspect is to allow multiple users to work on the same system simultaneously. They can benefit from working on the same data whilst also preventing users from editing the same data at the same time. The TSM data model was developed to deal with large amounts of recorded data. Therefore it has all the necessary functionality to manage time series on such a level. Another important topic is time series classification. One of the major differences found, is the distinction between equidistant data (e.g. 15minute water stage values) and non-equidistant data (e.g. rainfall event, singular observations).

DATA PROCESSING

Data validation

Identifying abnormalities in the data is normally the first step of the validation process. As a result of malfunctioning of field sensors and other devices, or due to the maintenance of those devices, recorded data is likely to have a range of different quality that has to be corrected. To help the user locate data of poor quality, KISTERS TSM has auto validation routines. These routines can be used to apply the organizations' business rules to validate the data using predefined criteria and place remarks for user notification each time one of the criteria is violated. Examples of these quality controls are identification of gaps, maximum/minimum exceedance of thresholds, variations from to neighbouring stations or other user defined formulas and rules.

Data editing

The stored data can be accessed through the graphical user interface (GUI) of the WISKI workbench (Fig. 2). The WISKI workbench client is developed for MS-Windows platforms. Therefore, WISKI has a modern interactive graphical time series editor, to allow graphical editing of time series. Following the data flow through the system, WISKI is able to deliver the following processes and functionalities.

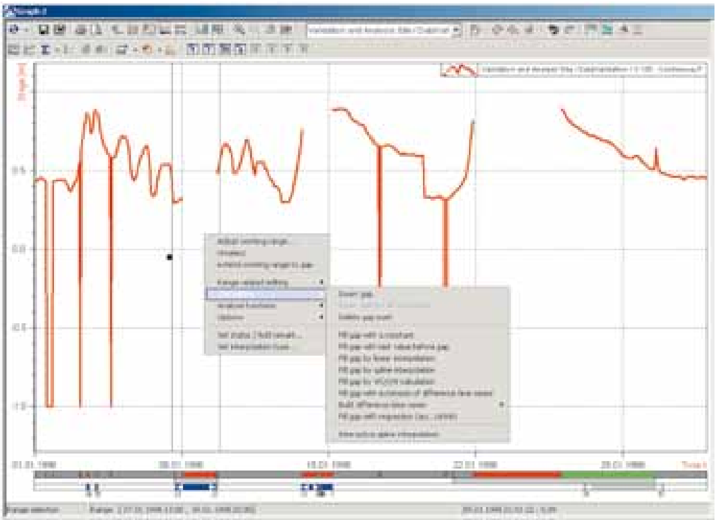

Fig. 2. Interactive Data Editing and Validation in Graph

Data correction

For editing purposes, WISKI provides efficient data editing functionality using an interactive graph or table to allow graphical editing using the computer mouse and keyboard. Examples of functions and methods to correct errors in time series are the filling of gaps with interactive linear or spline interpolation, adjusted data from neighbouring stations or regressions or e.g. vertical or horizontal stretching of the trace.

WISKI allows 255 user-defined data quality flags to be assigned to each data value. This will identify the primary quality for example Good, Suspect, Estimated, Unchecked, Missing. Standard remarks from a pick list and free text comments added by users can be used provide additional information about the data.

WISKI keeps a record of who changed the data, for which period and automatically records the name of the method applied for the predefined editing functions listed above. The original data is not edited; instead a "production" time series is defined which stores a copy of the original values, which can be viewed, edited, and validated.

Working within a multi-user environment also implies being able to regulate access to the data by defining roles with corresponding access rights. This allows the hierarchy of the organization to be represented by the information system.

Derived and summary values

While validation takes place on high resolution time series, WISKI calculates the derived summary time series for further analysis and dissemination. The daily, monthly and yearly values are derived from the high resolution time series and are calculated automatically. In combination with built in reports, the user can rapidly generate these reports without exporting data to external publishing software. An internal mechanism ensures that each time the underlying high resolution time series are modified, the derived summary time series are updated automatically. This mechanism, prevents a user from publishing or exporting out of date data, and prevents them from having to keep a record of when to update derived time series (Kudo *et al.* 2009).

Rating curves and statistical analysis

WISKI has a fully integrated rating curve editor. Based on flow measurements, and other filed collected data rating curves can be managed without having to leave the main application. Following validation of the stage data all necessary functionality is available to perform the complex task of defining the water stage/flow relationship of a river. The flow is calculated automatically, or can be triggered by opening the corresponding time series in a graph or table.

For the advanced analysis of recorded data, WISKI offers statistical analysis tools such as linear and non-linear regression analysis, statistical analysis of durations, flood and low flow frequencies, double mass plots, rain storm frequency analysis. The WISKI statistical analysis tools were developed in close collaboration with hydrologists, and are based on national and international standards, such as the United States Geological Survey, the World Meteorological Organization and ISO standards.

Data dissemination

WISKI has an open data model based on the core TSM/WISKI model. The user can add attributes and objects as required by his organisational structures and workflows. A generic C++ & Java-APIs for report generation, external data access or model integration is integrated into WISKI software. This API has the same flexibility and security in data access as the software itself.

Additionally, the easy to learn WISKI scripting language KiScript brings flexibility to the user to add their own calculations, queries, reports, or exports into the system and interface to Excel or other software products.

WISKI standard reports, written in KiScript, can be adopted easily to an organization's reporting requirements. Today, the Internet has become one of the key gateways for exchanging information. For this purpose a web module has been developed for WISKI for disseminating data on the Internet/Intranet using a web browser as a GUI. Moreover, WISKI supports fully automated services such as the sending of data files via FTP (file transfer protocol) or email.

MAPPING AND GIS INTEGRATION

The display of spatially referenced information is made in several ways – following the different objectives required by the user:

The WISKI Web provides browser based access to the data and shows maps with station locations.

Data can be published based on services like WaterOneFlow, WFS, WMS, and Oracle Spatial and may be used in all applications using this protocols.

The WISKI-ArcGIS extension retrieves information from the database and integrates it into the ArcGIS session; subsequently the whole range of ArcGIS-functionality (e.g. mapping, selections, classifications, exports...) is available Simple maps can be shown in the WISKI client software for navigation purposes (Kudo *et al.* 2009).

WISKI 7 IN FOCUS ON SHOW CAVES MONITORING – SCENARIO EXAMPLE OBJECTIVES OF SHOW CAVES MONITORING

Modern technological applications used for measuring equipments and software solutions brings the most effective way for environmental monitoring and protection. Special approach is important for show caves monitoring where number of visitors could have a significant impact on local microclimatic and microbiological balance. The great improvement achieved in the last decades are mainly due to the new technology and particularly to the inexpensive data loggers which record unattended a great number of data (Cigna 2002). Presented scenario is based on general knowledge of cave monitoring using fictive metadata and time series.

METADATA STRUCTURE

Stations are located outside around the cave on the surface and inside of the cave system. All stations are grouped under the Site which could be cave respectively name of the cave. There are several station types in monitoring network (Fig. 3). Depending on measured parameters the station belongs to one or more station types. Each station type has own tab page with relevant additional attributes.

Monitoring parameters are relevant hydrometeorological phenomena on the surface as water level, discharge, water temperature, water quality parameters air temperature, precipitation, snow, etc. and inside the cave as water level, discharge, water temperature, air temperature, relative humidity, wind direction and velocity, water and air quality as CO_2 concentration or radon concentration. At the entrance of the cave is localized presence sen-

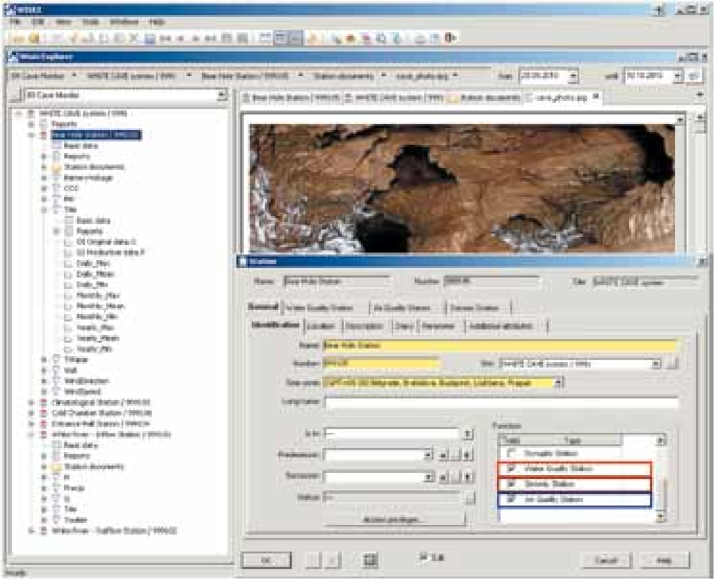

Fig. 3. Metadata and time series structure

sor for additional parameter as number of visitors inside the cave. Each measured parameter is assigned to specific station type but it could be also general for all station types.

Station documentation contains pictures, schemas or equipment certificates stored in various formats, as well related web links. While the WISKI has own user policy the Work folder is arranged by each user customizing his working field.

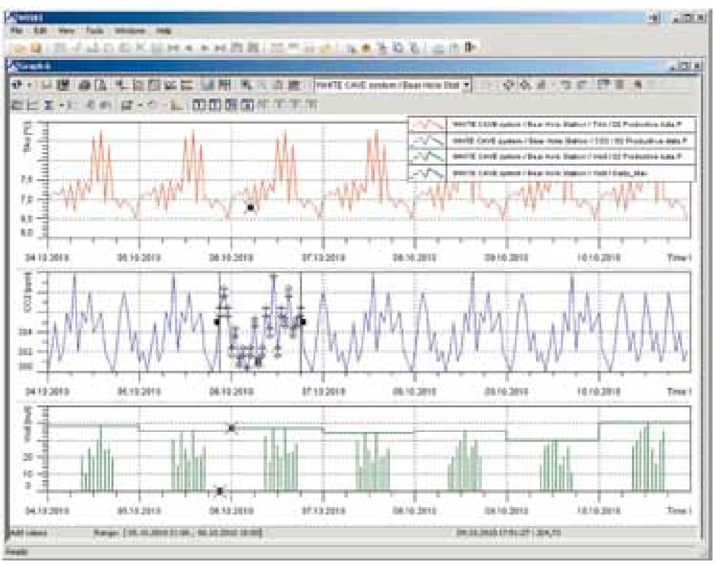

Fig. 4. Graphical presentation and time series data correction

DATA ACQUISITION

Monitoring of different variables in heterogeneous measurement network with various sensors and data loggers, types and formats of data input requires a special data acquisition approach. These tasks are provided by online data acquisition system with several possibilities of transmission methods (GSM, FTP, TCP/IP). Data are imported from file formats as zrx, csv, xml or using configurable importer tool for specific data structure or just with simple copy and paste from spreadsheet as well.

TIME SERIES STRUCTURE AND DATA PROCESSING

Basic structure of time series data consists of original data, productive data and computed or aggregated time series as characteristic values during selected time period (day, month and year). In case of several sources of original data e.g. automatic station and observation, both sources could be merged into one productive time series. Special programming tool can compute new time series from time series of different parameter. For example the sediment load is computed from sediment concentration and discharge.

Analyzing and verifying the data in graphical environment provide an effective work for operator (Fig. 4). Using various statistics the operator can evaluate natural and anthropogenous influences on cave environment.

SUMMARY

WISKI system integrates and significantly improves data and information management practices at various organizations world wide which are involved in environmental monitoring. The WISKI system provides a reliable and flexible archive enabling a central, consolidated source of information. It can provide a modern software platform with sufficient flexibility to encompass future business change and data demands. Its implementation within different authorities reduces costs for support and maintenance, frees up staff resources to improve data quality, undertake more comprehensive analysis and to convert data into information for managing the environment.

Binding with other KISTERS solutions as SODA system for simultaneous online data acquisition, KiDSM for automation of services and Alarm Manager for information and message management in exceptional situations WISKI system provides a whole range of complex and effective monitoring.

Acknowledgment

KISTERS is very grateful to International Show Caves Association and Slovak Caves Administration for the possibility to present this short paper. Thanks to all speleological researchers for their inspirational works and ideas on such interesting and important field of environmental supervision as the cave monitoring.

KISTERS would like to thank all cooperative customers who are improving the KISTERS TSM based hydrological information system WISKI.

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