Ambient Air Quality Data Management and Data Integration

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Abstract

Air quality monitoring as well as air quality data management and network integration are difficult tasks to perform. The more complex the tasks are respectively become the more easy to handle and transparent mechanisms are needed. Having an experience of about 20 years in the field of air pollution monitoring, we developed strategies and solutions we implemented in our new system called UWEDAT-NT.

UWEDAT stands for a new environmental monitoring system based on Windows NT/2000, primarily used in the field of ambient air quality monitoring. But the kernel of the system is designed and implemented in such a modular and flexible way, thus it is possible to customize this information system in any thinkable way. Within the following chapters we describe the UWEDAT System focusing on the data management tools, quality assurance, data and network integration and the UWEDAT principles.

1 Uwedat-System

In general from the station computer data is sent to the central host, using different kinds of telegrams. These telegrams are implemented within the communication server (UwedatCS). This part of the system is the so-called central network manager, which is responsible for handling all the communication to and from the measuring stations as well as the communication with the database.
As mentioned before the principal idea behind this is that the UwedatCS transfers the measuring values from the measuring station outside into the host's database. Three separate server processes are attached to this very complex task:

- The FORMULA Server (UwedatFS): A high speed database interface to handle mass data (time series)
- The Limit/Threshold Server (UwedatGS): A monitor to check the measuring values against any kind (user definable) of limit violation.
- The Message Server (UwedatMS): A service to process messages according to message datapoints. These message datapoints are established by the user or generated by the system.

The Uwedat-Navigator (UWENAV) is a tool which allows the user to parameterize and to operate the monitoring network. It is clearly stated, that before any data can flow into the database, the monitoring network has to be defined. All this information (i.e. structural metadata, [lit.Ref]) needed, like operator of the network, related hosts and monitoring stations as well as pollutant parameters is configured with this tool.

1.1 FORMULA Server

The FORMULA Server is one of the main services in our system. To overcome the troubles you have when writing mass data (like time series) into a data base or retrieving it from a database it was necessary to design a high speed mechanism. This mechanism performs

blocked records with a fixed length instead of a record for each measuring value and stores it block-wise in the database.

1.1.1 FORMULA principles

The monitoring data, comprising of the measuring value including quality information (so-called status information), are put into or retrieved from the database using the FORMULA-Server.

The principles of the implementation is that the FORMULA-Server handles so-called "FORMULA Expressions". FORMULA expressions are strings which get parsed, compiled and evaluated by the FORMULA-Server. The result of such a FORMULA string is always a time series. This pre-compiling on the one hand and the blocked storage mechanism allows data retrieval of half hour mean values of six different parameters (including all quality information) over a whole year within a few seconds.

All data are based on and stored as a special kind of mean value time series in the host database, respectively in a special mean value archive (typically half hour mean values archives or ten minutes archives). All other, especially higher aggregated mean values are based on the measuring values stored in such a "source archive".

1.1.2 Generic mechanism for flexible access to complex archives

All time series data are stored in the UWEDAT system in tables called "Archives". These archives are structured in a way to support our proprietary FORMULA query mechanism. Usually the original measuring value (first measured value) and the checked and evaluated value, with the full status information, are kept in these archives.

Depending on the user requirements it is possible to define different kinds of archives for example for half hour mean values [HMW], ten minutes mean values[MM10], for daily mean values[TMV] etc. Typically we base all our aggregated values (for example 3-hourly mean value) on the smallest available time base (typically half hour mean values or ten minutes mean values) if not configured otherwise.

On a data request the FORMULA server looks up these archives and can decide according to the archive definition table in a generic way which type of archive and building rules it has to use and most important which result type has to be returned.

2 Data management using UWEDAT-Tools

There are several tools available in the UWEDAT system which allows you to perform an easy and simple data management. We will briefly discuss the three main tools in this chapter:

2.1 Uwedat-Navigator (UWENAV)

This tool is necessary for the efficient maintenance and parameterization of the environmental database. This user interface is based on ORACLE Forms.

The idea behind the concept was to have an application available, that is close to the look and feel of MS-Explorer. That means, that we have on the left hand side of the user interface an hierarchical browser and on the right hand side the related properties to each of the left hand side items (see Figure 1). Thus, you click on an item in the tree window and you will get displayed all existing properties in the right window.

2.1.1 Data management hierarchically

The browsing or editing (data entry) part of UWENAV can be switched into three different tree views. Depending on the mode set within the menu bar “View” the tree gets displayed ordered by

- “*all operators*” (main center as well as regional centers) or
- “*own* measuring *stations*” or
- “*by parameters*”

and the parameters in the property window can be displayed, entered or updated.

The icon in-front of each item in the tree shows, if a measuring station or a parameter is active or inactive (red crossed icon means deactivated parameter or station) Clicking on an icon or item expands or collapses the tree at the pointer location.

On selecting “*all operators*” the tree expansion shows the related measuring stations of a monitoring center. In case of viewing “*all stations*” the expansion shows all related parameters of a station (datapoints). On selecting “*all parameters*” the expansion displays all measuring stations where this parameter is measured (equipped).

2.1.2 Managing properties and settings

Clicking on an operator’s icon or name its properties are displayed on the right hand side (see Figure 1). All information about an operator as well as it’s description can be entered or updated here. From the view of user interface design we have consequently kept this structure to enter all properties and settings beginning with the operator’s description down to each single parameter monitored in the UWEDAT system.

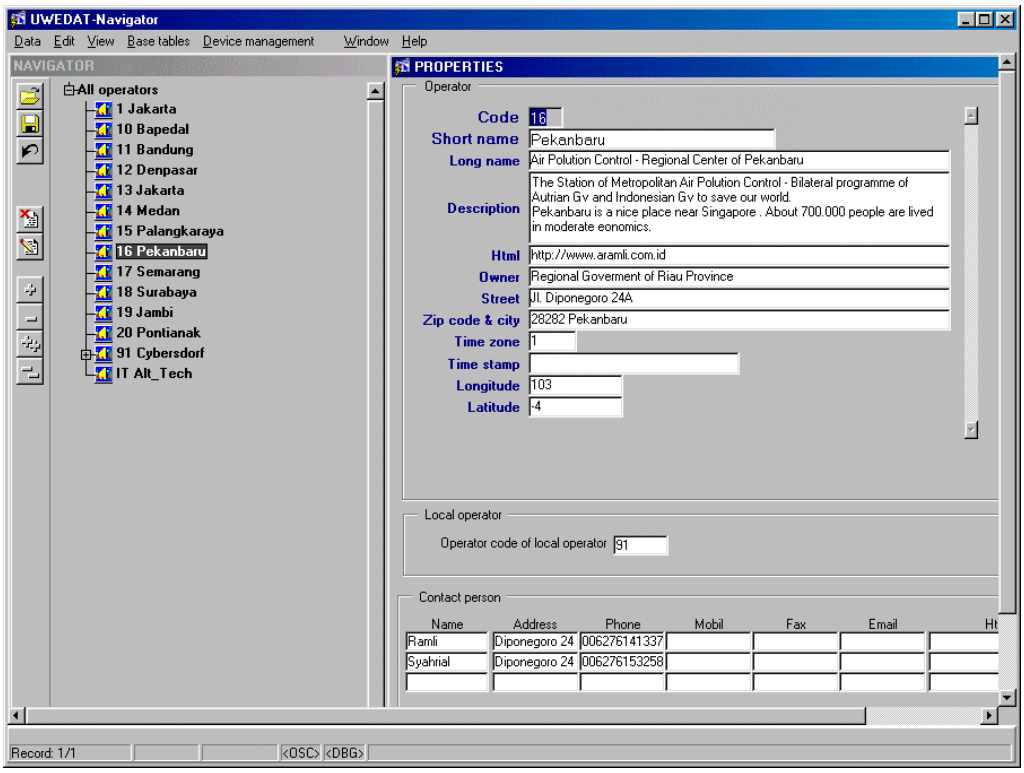

Figure 1: Example for operator's properties (test data)

Further essential database parameters (like limits, phone schemas, components etc.), which are managed with this tool will be discussed in the final paper

UweMon is an utility to visualize the situation of the air quality monitoring network and to achieve basic control tasks within the network. UweMon links to the database of a monitoring

network and polls the tables for state changes or updates. These state changes are visualized in an hierarchical way analogous to the configuration tool UWENAV.

The UweMon program runs on the central host server. It is connected to the Uwedat services like UwedatCS (Communication server), UwedatFS (FORMULA Server) and UwedatMS (Message Server). It allows to interact with the measuring stations of a monitoring network. Several control actions can be initiated, like: start communication with the actual selected station or reload data from station.

The layout of the UweMon user interface is very similar to that of the UWENAV tool. All operators and stations of the operators are displayed in an hierarchical way . Differing from the UWENAV tool, UWEMON displays all activities within the network. Typically active messages or actual measuring values of parameters in a station are displayed.

2.2 Quality assurance and data inspection

The data inspection tool is a tool for interactive validation and evaluation of stored measuring values. The values that have to be checked are displayed on the screen of a Windows PC.

The common principle is that all measuring values can be validated in a transparent way. For quality assurance reasons changes of values must be documented by the user. Automatically stored are the username and the changes he made. Further on the user may comment on why he did and how he made these changes. Additionally manipulated values get a separate identification flag. Uncertain values are marked as invalid and restored with a quality flag in the database.

To facilitate the daily work it is important that so-called profiles can be defined. This is done within the “data inspection manager”. A profile is a kind of configuration file, in which so-called evaluation groups consisting up to six parameters (components) are grouped together. These profiles are stored in the database and are reloaded when opening a new session.

Depending on the settings made in the “data inspection manager” up to six components can be evaluated simultaneously. The functions needed to perform the checking and evaluation of data are directly executed from the user interface of the “data inspection graph”.

3 Uwedat-System integration into the overall Austrian Immission Monitoring Network

All operating Austrian Air Quality Monitoring Systems (different monitoring networks operated by the federal provinces) have to supply their data into the overall Austrian Immission Monitoring Network (operated by the Federal Environmental Agency Austria).

Uwedat handles that via a client/server architecture based on RPCs. Depending on the functions which have to be executed the Uwedat-System once plays the role of a client (for example when meta data are exchanged) and on the other side it functions as a server (for example when time series data are requested).

The final paper will describe that procedure more detailed.

4 Conclusion

in final paper

5 References

in final paper