Integrated Quality Control Functions on AWS-Level
Gealog SG Station Manager

Gerhard Pevny, Dietmar Pindeus
Logotronic GmbH, Phorusgasse 8, 1040 Vienna, Austria
Tel: +43/1/5872976-0*, Fax: +43/5872976-41,
Email: gerhard.pevny@logotronic.co.at, pindeus@logotronic.co.at

ABSTRACT

Hydro-meteorological networks are collecting data which are subsequently used for the preparation of significant decisions within politics, planning, emergency management and many other domains. Therefore it is essential, that the network operator's "product" should be of the highest quality level. The main "product" of measuring network operators are correct measurement values which, registered comprehensibly, are transferred to the measuring network centre and processed in order to submit the required information.

In the last years Logotronic developed a completely new measuring station manager instrument called Gealog SG, which has implemented, perhaps as first instrument on the market, a complete "Integrated Quality Control System". Many tools, designed both in hardware as well as in software are existing now to implement an automatic quality identification for each individual measured value. This quality information is called "Quality Tag". It is stored and transferred in all cases together with the corresponding measuring value. This lecture shows the various possibilities for automatic checking on hardware level of the measuring system components like sensors, measuring transducers and auxiliary equipment like ventilation units, heaters, power supplies, etc. Additionally all implemented functionalities are presented for mathematical processing of different quality inputs to compute complex quality criterias. Finally the result of the computation of the quality information is classified according to a classification scheme based on WMO drafts. This classification finally leads to the Quality Tag of the corresponding measuring value. Based on this Quality Tag and especially changes in the Quality Tag actions can be taken i.g. automatic alarming, switching to redundant sensors etc. The basic principle is: Detection of an error in advance before the error shows influence on the measured time series and immediate alarming to the maintenance team.

Starting Point

There are lots of technical standards already existing regarding the measurement of meteorological and hydrological variables. The CIMO Guide (Guide to Meteorological Instruments and Methods of Observation WMO No. 8) contains extensive technical recommendations how to measure meteorological parameters. The CIMO Guide also contains some chapters describing the basics of quality control and quality management procedures. Nevertheless there are no details given for quality control procedures on AWS level. On the other hand CIMO Guide Part II - Chapter 1.3.2.8 (Measurements at Automatic Weather Stations - Quality Control) specifies, that any specification for an AWS should state explicitly a minimum set of quality-control procedures to be used. Logotronic has started therefore to develop a set of standard quality checks and procedures which are presented in this paper.

Logotronic started about 5 years ago with the concept for a new datalogger or better station-manager which should have some basic features:

- Using most advanced technology in hardware and firmware
- Implementation of many of the actual standards regarding interfaces between datalogger and sensors as well as interfaces between datalogger and network centre
- Very comfortable user interface for easy management of the additional functionalities
- Based on this platform implementation of an extensive automatic quality control system

The high computing and storage capabilities of modern electronic components make it possible to have nearly PC-processing power at site without loosing on the other hand the specifications for AWSs regarding minimal power consumption and wide operating temperature range. Additionally using modern data transfer media (GPRS, Meteosat HDR, ...) with a higher data transfer speed at lower costs allow the transfer of higher quantities of data and therefore the integration of additional quality information. So the planned station-manager was a perfect platform for the implementation of the quality control functionalities.

Where should quality control be applied

Quality control must be applied on all levels of the system, in our case the components of the measuring network.

1. Control and reporting of user interventions at the AWS

2. Monitoring of of the working environment of the AWS

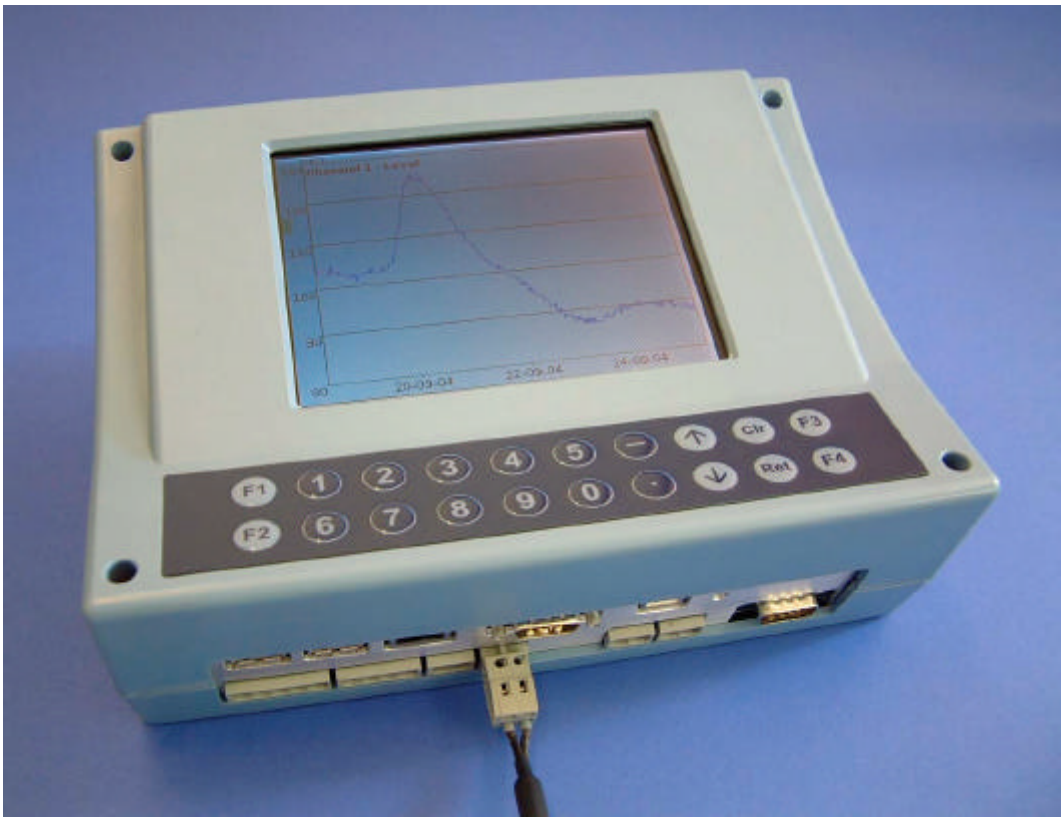
3. Quality control of the sensors
   - Hardware orientated checks
   - Plausibility testing

4. Check on the AWS´s system time (real time clock)

5. Quality control of the data transfer lines to the measuring network centre

Gealog SG Station Manager

Finally the development led to the new Gealog SG station manager which is now available. The first implementation of the new Gealog SG in a countrywide measuring network will be in the Austrian TAWES network consisting of about 200 stations.



The basic philosophy for the definition of the quality control procedures was:

Detection of an error in advance before the error shows influence on the measured time series.

The following paragraphs will give an overview about the various functionalities of Gealog SG regarding automatic quality control functionalities.

User Identification, LOG-File

As an indispensable requirement we see the identification of users communicating with the AWS both locally or remotely. Therefore Gealog SG has a complete system of user-IDs and passwords. Each user who wants to operate the AWS has to identify itself by an Log-In procedure, he has to finish his work by Log-Out. The information is stored automatically in a so called LOG-File together with date and time. Further on all user operations which change the status of the AWS (i.g. changing of parameters, recalibrations) are automatically stored in the LOG-File, each entry with date, time and user-ID. For instance sensor recalibration, maintenance works and repairs are documented fully automatical. The LOG-File is transferred together with the recorded data to the network centre and gives a perfect report about all user operations at-site.

Monitoring of the working environment and internal parameters of the AWS

Every measuring system has well defined limits of use regarding the environmental parameters like operating temperature, supply voltage etc. Only if the limits are obeyed the system can produce the results within the specified accuracies. So it is important also to monitor this type of parameters. The Gealog SG has therefore implemented a set of "internal measuring channels". The Gealog SG datalogger continuously monitors:

- Station battery voltage
  The time series of the recording of the station battery shows clearly, if the lifetime of the station battery is at the end.
- Voltage of the buffer battery used for the internal real time clock.
- Internal temperature
  Too high internal temperature can cause many problems like temporary, unreproducable errors, short lifetime of the equipment, especially batteries, too high measuring errors

By use of the values the system can detect automatically if it is operated in the specified ranges of environmental parameters

Quality Control supported by the Galog Measuring Interface concept

The Gealog system is based on the fact, that the single sensors are connected via Gealog Measuring Interfaces to a standardized RS485 fieldbus. The design of these measuring interfaces is relatively easy and can be done in a short period of time. After this development the access to the sensor is done via the Gealog RS485 Fieldbus and all functionalities of the system can be applied to the sensor. That means, for the specific sensors perfectly suited measuring interfaces are available which do not only do the measuring task, but also have sensor specific quality checks implemented:

- Test on loose wires and broken wires for passive sensors (tipping bucket contact, Rtd100)
- Check of auxiliary equipment by i.g. measuring the rotation speed of the fan for ventilation of the air temperature sensor.
- Check of the heater function for heated sensors by current measurement in the heater line
- Use of status information of intelligent sensors to prepare quality information
- Protocol check for sensors with serial interfaces
- etc.

Additionally in the last years there was a big development towards intelligent sensors. This sensor intelligence makes it possible to have quality checks directly implemented in the sensors. The process of development of this sensor-internal quality check procedures has just started, but will be a wide field for improvement in the future. As a matter of fact the station manager should use this valuable sensor quality information and should integrate it into his own quality control system.

Plausibility checks - Standard checks

Implemented standard plausibility tests:

- Threshold values to define a plausibility range for each single parameter
- Variability test
  The Gealog SG takes the data of a specified time period and checks, if the variations within this time period are exceeding a defined threshold. The same test can be done for too low variations. Some sensors produce "noise" when they are going to fail. This noise can be detected easily by use of this variability test.
- Redundant sensors
  For important parameters (i.e. water level sensor for flood alarming) the sensor should be doubled. In that case the measuring values of both sensors can be compared and the difference can be tested on a specific threshold value. For this difference the above test on variability can be applied to give a reliable quality information. This test can be very valuably because there is the possibility to detect long term offset shifts or gain shifts which otherwise can remain undetected for a long period of time.
  Gealog SG offers the possibility to use "the better sensor" for further processing (i.e. alarming), what means, that sensor with the better quality status.

Plausibility checks - User specific checks

On a higher level of processing, the Gealog SG is using mathematical formulas to compute various criteria for the plausibility of the measuring values. The mathematical fomulas can be inputted in plain text in a standard mathematical presentation. For each measuring channel these formulas can be defined. This feature is used to define user specific plausibility checks which can be developed according to the practical experiences and requirements. There is also the possibility to have "mathematical channels" which are only used for computations.

I.g.: Formula for monitoring of a sensor heater:

(Val(C1)<3)&(Val(C2)=!0)

C1 Measuring channel for air temperature
C2 Status of the sensor heater detected by the Gealog Measuring Interface

If the air temperature is below 3 degrees the sensor must be on (Status=1)
The formula produces "true", if the sensor heater fails. This information can be used to set a plausibility error for the corresponding measuring value of the precipitation gauge.

Checks on the system time

The Gealog SG can synchronize his real-time clock from the network centre. At the synchronization the time difference between old and new setting of the clock is computed and checked. If there is a too high time-shift a time-error is detected. Measuring values, influenced by the clock synchronization are marked.

Quality Tag

All of the quality checks lead to the so called Quality Tag, which is assigned to each stored

measuring value. The information-set for each data item is therefore:

- Time stamp
- Measuring value
- Quality Tag

The measuring value and the Quality Tag are stored, transferred and processed together on all levels of the system. Gealog SG is using a single letter as Quality Tag.

Predefined Quality Tag values

Identifier	Description
A	No errors identified
B	Plausibility error detected Measuring value existing, but possibly erroneous
C	No measuring value existing, fatal error
D	free
W	Maintenance Sensor is switched manually to the maintenance status Measuring value existing, but possibly erroneous
Z	Time error detected Measuring error influenced by a new setting of the internal real time clock Measuring value existing, but possibly erroneous
K	Manually inputted check value

If there are mathematical computations defined between different measuring channels, also the Quality Tags are used in the computation. The result gets also a Quality Tag, normally the worst one of the used measuring values in the formula.

Automatic Alarming

Changes in the quality status of the measuring channels can be used for immediate alarming of the network centre.

Support of manual quality control

Gealog SG comprises also some components which enable the user to perform very easily some additional checks.

- Integrated graphic display with marking of values with Quality Tag below "A" in the graphic output

- Video camera
  Gealog SG has the possibility to connect directly a camera system for monitoring of the environment of the AWS. This images are recorded and transferred to the network centre where the user can have an on-line look at the measuring station to see its actual status (snow, grass too high, damages on the equipment, flooding situation, ...). We see the integration of pictures in the future as an important part of the station´s metadata.

Summary and conclusion

The use of this quality control functionalities on AWS level should lead to a widely automatic quality management system for the whole measuring network by using the AWS quality information in automatic procedures on network centre level. WMO is actually setting up the WMO QMF (Quality Management Framework). A very important part would be to define standards and recommendations for quality control on AWS level which could be perfectly done by revising and

extending the WMO Guide No. 8 which actually comprises some general recommendations in Part II and Part III. A part of this additional recommendations could be:

- Integration of quality data into the standard data sets
- Definition of a quality tag system
- Definitions of sensor specific or measuring parameter specific recommendations for quality checks and procedures on AWS level
- Recommendations for AWS metadata including "on-line metadata" like actual images of the station

All of this internal quality check procedures on AWS level should lead to a widely automated ISO9001 compatible quality control system where the routine documentations required by ISO9001 are reported automatically with a minimum of additional manual reporting.

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