The new synoptic-climatological station AMDA in the DWD primary network

K. Klapheck and K. Wolff

Deutscher Wetterdienst Frahmredder 95 D-22393 Hamburg
e-mail: Karl-Heinz.Klapheck@dwd.de
Karsten.Wolff@dwd.de

Abstract:

The German Meteorological Service is currently modernizing its ground based and upper-air observing networks. Part of these networks are 160 synoptic weather stations. They will be equipped with a new measurement technique during the years 2005 to 2007. Their sensor equipment and possible modes of operation are explained. They can work fully automatically or by including observer information. Also monitoring and administration of the stations, data communication and archiving of data, alarm handling and quality control of the measurements are discussed.
The paper presents station design, data flow and network functions and some results of the operational test phase.

Introduction

The primary network is the backbone of ground based observations made by Deutscher Wetterdienst (DWD). At present it includes about 80 stations with full-time observers resp. observers at times and 80 automatical stations, whose number is trending upwards. A secondary network with voluntary observers and a reduced amount of data is supplementary [1] and in operation.
In DWD the objective is to increase the data of ground based observation in time and space as well as to improve the quality of data in both networks. So forecasters' as well as climatologists' requirements will be fulfilled. Additionally the operation of the network shall be strongly automated and the maintenance shall have less expenditure. Therefore now the primary network will be equipped with modern measurement systems called 'Automatische Meteorologische Datenerfassungs-Anlage' AMDA in DWD-jargon, type I for manned operation and type II for unmanned operation. The system was designed and is produced as 'Meteodea E100' by Ernst Basler + Partner, a German meteorological software company. The company also develops most units of the network centre.
The secondary network has already been equipped to the most part with a technique called AMDA III, developed by another manufacturer with a different design.
This paper concentrates on the properties of AMDA I / II. It shortly introduces the sensors actually coupled, the data communication components and the functions of the central network control. Finally the state of instalment and the future tasks are mentioned.

Sensors

The sensors are installed in a standardized field covering an area of 25 m x 25 m. In special cases the wind sensors can be far outside this area, then they are coupled wirelessly to the system. Also radiation sensors can be mounted outside the field to avoid shading. The pressure sensor is installed near the system computer (inside a building or a container). Generally the same types of sensors are used at all stations in both networks except at certain mountain stations, where due to the extreme climate the wind measurement is better done by a sonic anemometer than by a conventional wind vane / rotating anemometer. There also the temperature / humidity measurement with a heated dew point mirror will probably remove the iced radiation shields.
For a number of meteorological quantities intelligent sensors with integrated computing components are developed for automatic operation. These sensors transfer data in data telegrams

via a digital intersection. One of them is the Present Weather Sensor (PWS), an important step in automating eye observations. It generates a weather code as well as particle size distributions. PWS will be installed at fully automatic stations.
Radiation is measured with the first class instruments pyranometers and pyrgeometers only at certain manned stations. At unmanned stations a second class instrument called Scanning-Pyranometer-Pyrheliometer (SCAPP), a development based on the sunshine indicator, will be used. It is planned to measure the state of soil too, but no sensor is selected till now. In table 1 the meteorological parameters together with the accompanying measurement principles and sensor types are listed.
Cameras installed at some stations are not integrated in AMDA but represent a separate system resp. network [2].

Data acquisition and data processing

The essential characteristics of the AMDA system are
- completely modular design of hardware and software
- all sensors connected via PROFIBUS, Europe's most common industrial field bus
- high reliability due to redundant subsystems
- flexible adjustment and extension of measurement data processing by configuration
- standardized internal communication via CORBA protocol
- standardized external communication via XML protocol
- comfortable input and visualization of data by the observer or service personnel
- usage of Open Source Software

Hardware
According to the hardware concept an industrial server-PC works as the station computer. It is equipped with redundant hard disks and power supplies, with an integrated PROFIBUS controller and a multi-channel RS485 serial interface card. Buffering of supply voltage by batteries is added.
The system operates reliably, is capable of further extensions and is equipped with remote monitoring functions by a web interface independent of the PC. The system is mounted in a 19" rack and works at a monitored temperature range of –5° to +50°C. It is placed either in a building (manned station, AMDA I) or a container (unmanned station, AMDA II). At manned stations the observer uses a separate standard PC as an AMDA client for data input, visualization and maintenance. The AMDA-LAN is connected by a router over a DSL or ISDN line to the headquarter.
All sensors in the sensor field are connected to the AMDA system via the PROFIBUS field bus, see also figure 1.
Components of the PROFIBUS are a controller card in the PC (the master), bus modules (the slaves) on the field and the connecting cable (two wire serial RS485). A maximum of 126 slaves can be placed over a length of up to 600 m. Repeaters allow further extension up to 10 km.
The AMDA system uses not more than three different types of bus modules for converting analogue and digital signals, which are electrical resistance, voltages as well as digital status levels and pulse frequencies. An additional type of bus modules is used to transfer all data telegrams from the intelligent sensors to the PROFIBUS. These modules are standard components from industrial automation technique with high reliability and conformability.
A concept of overload voltages protection is realized.

Software
The AMDA application system is designed as a set of independent components, see figure 2.
The component Data Acquisition is responsible for the data input from the sensors in fixed, configurable periods, depending on the sensor in a range from 4/s up to 1/min. Further data processing is done in the resp. component. It includes the computation of sums, averages, extreme values etc. An integrated formula language allows also complex calculations, in which the arithmetic expressions are part of the configuration.
The AMDA Client serves as an interface for observer and service personnel. At AMDA I visual observations of cloud type and amount, visibility, present weather, state of soil and other special

weather phenomena can be entered in comfortable dialogs, in regular intervals or arbitrary. The visualization allows numerical display of actual measured and computed values as well as status of sensors and components. Missing, erroneous and questionable values are attributed in different colours. (x,t)-diagrams with selectable scales show the courses of one or several parameters in one diagram. (x,y)-diagrams can be chosen to see two parameters in relation. Also polar diagrams are possible. Several diagrams can be placed on the screen. Of course tables of numerical values are possible.
Data and configuration exchange between AMDA and headquarter is done by the standardized XML (Extensible Markup Language) protocol. XML is a simple, very flexible text format derived from SGML (ISO 8879) for the exchange of data on the Web and elsewhere.
Additionally local or remote users can be connected over serial lines. Amount and format of the transmitted data are freely configurable.
Except for the Data Acquisition, which is coded in C++, the complete system is based on Java. The internal communication between all components uses the CORBA (Common Object Request Broker Architecture) protocol.
The Open Source database system postgreSQL is used by AMDA for local archiving of data and configurations. One of our objectives was to use Open Source Software whenever possible. Therefore DWD chose LINUX as operating system for AMDA.

Quality assurance

A central design principle of AMDA is to achieve high availability, plausibility and accuracy of data. Air temperature and humidity sensors are doubled. Status of all sensors and modules is regularly controlled, if necessary, alarms are triggered. The allocation of sensors and their technical specifications follow national and international rules. Recalibration of sensors and modules are part of the quality management plan.
Data processing includes algorithms to test the data values on plausibility. To each value in the output a quality byte is added. It classifies data quality and status of sensors and modules. A second phase of off-line quality management is done in the central database by the Quality Control and Monitoring System QualiMET [3].

Central control

Ernst Basler + Partner is developing a Network Control and Monitoring System, see figure 3. Essential server functions are calling the stations by a configurable schedule, storing all data in databases, administration of configurations, alarm handling and distribution of software-updates . Clients allow a comfortable survey and configuration of the stations. Geographical maps provide a quick overview of the status of all AMDA I / II stations, as it is already realized for the AMDA III network. AMDA III will be integrated into the new central control system too. Clients are installed in the DWD headquarter and in local service branches, access should be possible at any location in the DWD intranet. Reports like SYNOP, MREP etc. are generated in the Report & Product Generator. External users get access to the DWD database via a Gateway, which is separated from the intranet by a firewall.

Final remarks

Modern hardware and software technique enable us to increase the degree of automated observations as well as the amount of measured and computed data. The quality of data is improved and the maintenance of stations will be simplified.
A prototype test has been started in autumn 2004 and will be finished at the end of 2005. The installation of 160 regular station systems will start in summer 2005.
The operational prototype test includes a sample of 6 AMDA stations located in areas with different climatic conditions together with a prototype of the Network Control and Monitoring System. First

results confirm the reliability of the AMDA stations, of data transfer and of storage in the database. Quality of all data measurements is excellent.

Literature

[1] Klapheck, K. and Alsen, S.: Aufbau eines neuen Stationsnetzes für Klimatologie und Hydrologie. Proc. Deutsch-Österreichische-Schweizerische Meteorologen-Tagung, Karlsruhe, Sept. 2004
[2] Mammen, T. et al.: Digital video technique as a new part of the DWD observing network. To be published in Proc. WMO Techn. Conf. on Meteorol. and Environm. Instrum. and Methods of Observ., Bucharest, 2005
[3] Spengler, R.: The new quality control and monitoring system of the Deutscher Wetterdienst, Proc. WMO Techn. Conf. on Meteorol. and Environm. Instrum. and Methods of Observ., Bratislava, 2002

Table 1: List of sensors connected to AMDA

parameter	**sensor principle**	**Sensor type / manufacturer**	**intersection**
air temperature 2m	pt100 resistance	1/3 DIN class B / Friedrichs	analogue
relative humidity 2m	capacitive sensor multi-plate radiation shield	HMP45 A / Vaisala ‚DWD' / Eigenbrodt	analogue
air temperature 5cm	pt100 resistance	1/3 DIN class B / Friedrichs	analogue
soil temperature: 5, 10, 20, 50, 100 cm	pt100 resistance	1/3 DIN class B / Ketterer	analogue
precipitation vol./int.	electronic weighing	Pluvio / Ott	RS485
precipitation duration	IR-light barrier	Precip. monitor / Thies	relay contact
sun shine duration	Photoel. sunshine indicator	SONIe / Siggelkow	RS422
(alternative)	SCAPP (scanning pyrano-meter pyrheliometer)	‚DWD' / Siggelkow	RS422
global radiation	Pyranometer	CM11 / Kipp&Zonen	analogue
(alternative)	SCAPP		
diffuse radiation	Pyranometer	CM11 / Kipp&Zonen	analogue
(alternative)	SCAPP		
direct radiation	SCAPP		
atmosph. radiation	pyrgeometer incl. pt100	CG4 / Kipp & Zonen	analogue
wind direction	wind vane	Standard / Thies	Gray-Code
wind speed	cup anemometer	Standard / Thies	Pulses
wind (mountain st.)	ultra sonic anemometer	2D / Thies	RS485
snow height	ultra sonic device	SR50 / Campbell	RS485
cloud height	laser radar	LD40 / Vaisala	RS485
visibility	forward scatter instr.	DF20 / Degreane	RS485
present weather	laser disdrometer	Disdrometer / Thies	RS485
air pressure	capacitive sensor	PTB220 / Vaisala	RS485
state of soil			

Figure 1: AMDA hardware components

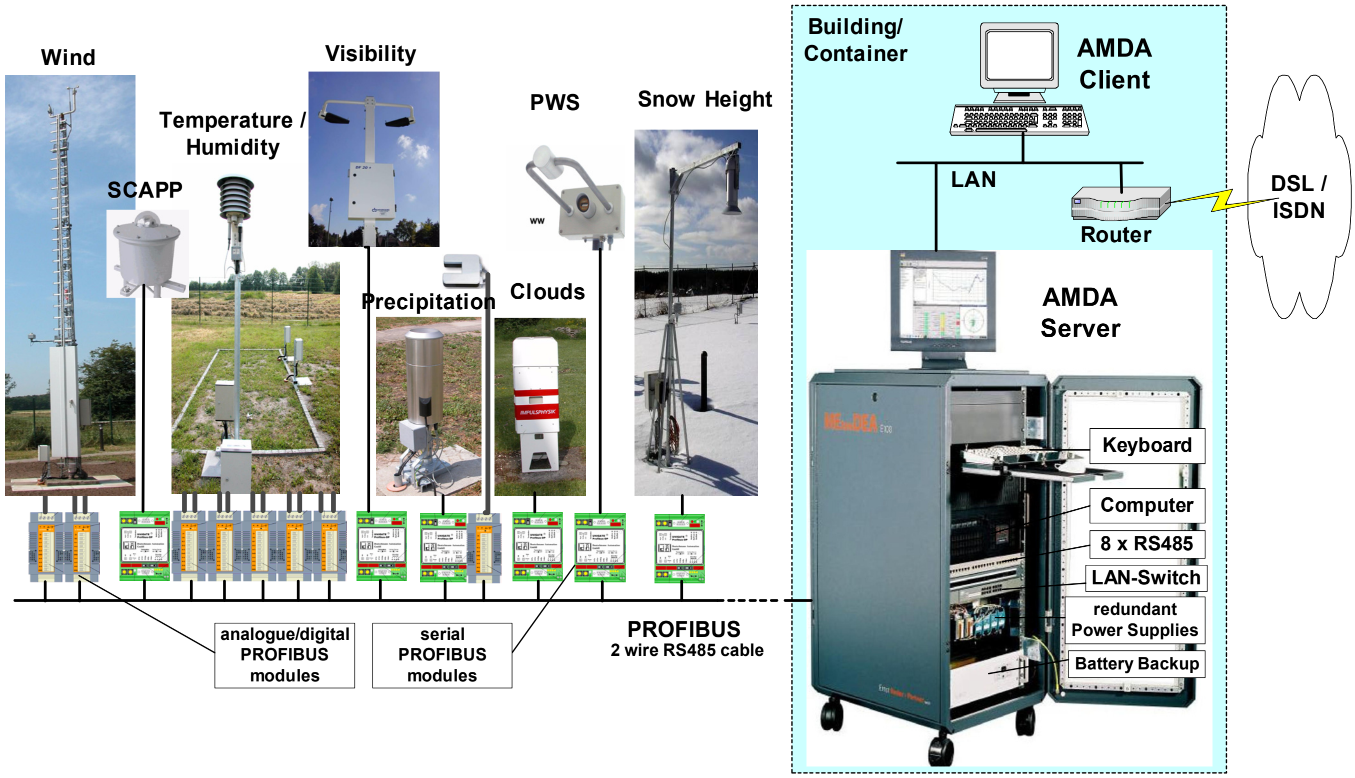

Figure 2: AMDA software components

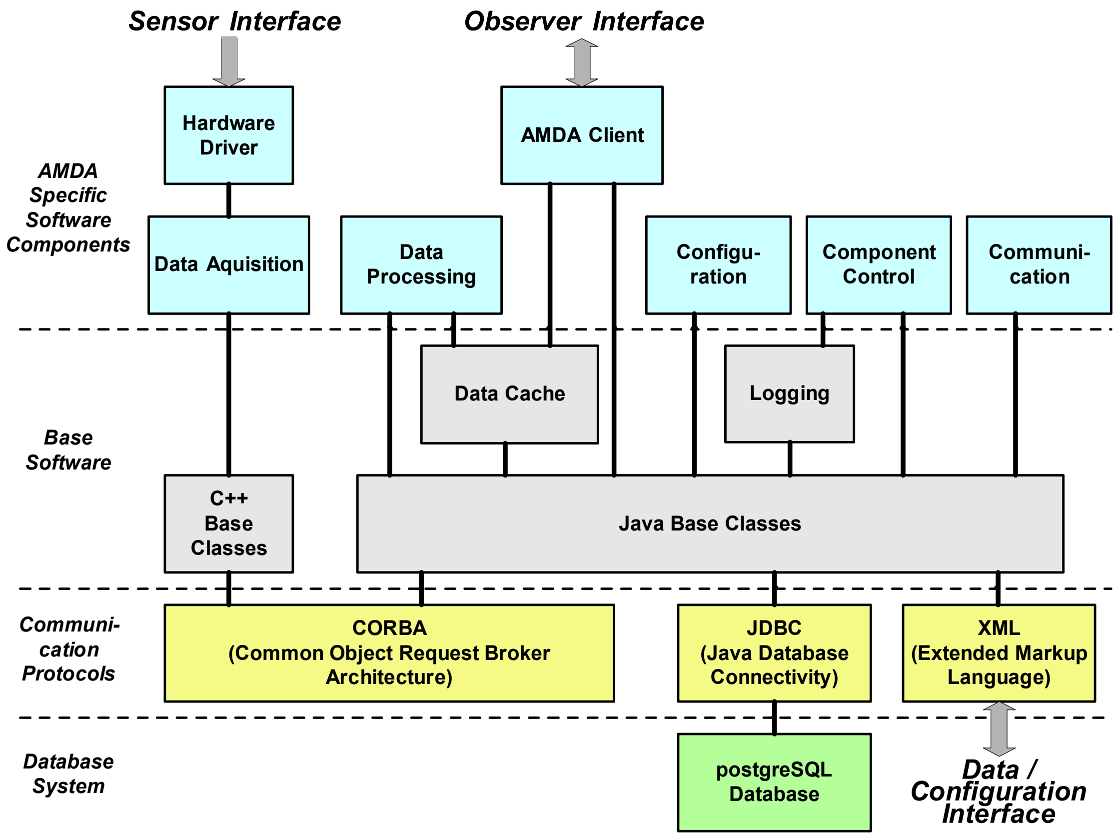

Figure 3: AMDA network components