METVIEW/ws - A DISTRIBUTED SYSTEM FOR METEOROLOGICAL DATA PROCESSING AND VISUALISATION

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Summary: METVIEW/ws is a system for visualisation and manipulation of meteorological data on Unix workstations. It has been developed as a cooperative project between ECMWF and INPE. The system is based on a distributed computing architecture and has an icon-based user interface. METVIEW/ws is mainly an interactive system, but incorporates equivalent functionality in batch mode. This paper describes : METVIEW/ws basic requirements, the data model, the system architecture and the user interface paradigm. It also reports the current status of the project.

1. INTRODUCTION

This paper describes a visualisation and processing system for meteorological data, called METVIEW/ws, that is aimed at weather prediction centres. METVIEW/ws enables operational and research meteorologists to access, manipulate and visualise meteorological data on UNIX workstations. Fields can be combined with satellite data and observations can be added. Applications include cross-sections, tephigrams, meteograms, generation of derived meteorological parameters , mathematical operations on fields and display of verification scores.

2. REQUIREMENTS FOR METVIEW/ws

The design objectives of METVIEW/ws are:

- To provide a platform for the development of meteorological visualisation software.
- To provide an interactive environment for the 2D and 3D visualisation of fields, observations and images.
- To provide an interactive environment for the retrieval of meteorological data.
- To provide tools for the manipulation of meteorological data, including derivations of new fields, comparisons and verifications.

- To be based on "de jure" or "de facto" standards to the extent possible and thereby achieve independence of any particular hardware platform.

The user perspective for METVIEW/ws is as follows (Câmara and Daabeck, 1991):

- The users are research scientists and meteorological analysts in a numerical weather prediction centre using a workstation with network access to a supercomputer.
- The workstation is used for data retrieval, data manipulation and visualisation;
- The workstation is linked via a network whose facilities provide transparent access to the data. Therefore, METVIEW/ws assumes that data are stored in the most suitable place and makes no distinction between local and remote files.
- The processing may be done either locally at the workstation or at a central computer that drives the workstation display.

METVIEW/ws is designed to be easy-to-use by using an iconic graphical user interface, based on Motif and X Window, which is specifically designed to minimise input requirements.

The user can also save global definitions, such as data manipulation formulae, drawing attributes, screen layouts, so that the user can make new drawings with a minimum of effort. It provides many services, such as full help facilities and custom configurability.

The user can define macro commands, in a high level language, to perform a sequence of operations. These macro commands may also be executed in batch mode.

3. THE METVIEW/ws CONCEPT

The general philosophy is that the user can create Metview/ws *icons*. An icon holds a *definition*, such as:

- a data retrieval request (*Original Data Unit*), which is a symbolic data description in meteorological terms. At run time, this description may be translated to physical file specification.
- a physical file specification (*Physical Data Unit)*, which contains a full path to a file on the network.
- a macro command or a formula (*Derived Data Unit*), which can define operations between other definitions.
- a set of visual attributes of a chart (*VisDef)*, e.g. colours and styles for contouring.
- a plot window layout (*PlotWindow*). which define the size and the organization (row/column) of plot areas.

Each icon is identified by a user defined name and is visually represented by an image associated to its

definition type.

An Original Data Unit definition held by the icon "MyRequest" may contain a data retrieval request written in the following language :

```
RETRIEVE,
PARAMETER = TEMPERATURE,
DATE = 860125,
STEP = 24/48/72/96,
LEVELTYPE = PRESSURE LEVELS,
LEVEL = 850
```

In this case, the user has requested the forecast based on 25 January 1986, with one meteorological parameter (temperature), one level (850 hPa), and four time-steps (24/48/72/96).
METVIEW/ws provides means to construct this request interactively and to send it to the appropriate computer for processing. The user can select one or more icons and then perform operations on them, such as edit, visualise or delete.

All definitions are written in a language based on MARS (Meteorological Archival and Retrieval System) language syntax. MARS language has been implemented by ECMWF for the retrieval of meteorological data (Hennessy, 1986).

4. SYSTEM ARCHITECTURE

User needs evolve over time and one cannot implement all user requirements at once. METVIEW/ws is, in its entirety, a very large system and it is not desirable nor feasible to aim at the implementation of the complete system at once. Therefore, METVIEW/ws is required to be a modular, extendible system, allowing new functionality to be added without rewriting existing code. There is a core of basic needs (accessing data, manipulating data, drawing charts) around which one can customise meteorological and climatological applications.

To satisfy these requirements, METVIEW/ws has been designed to be a distributed system. Each of its modules is a separate executable and these modules may run in different machines. Each module executes a service and may ask for other services to be executed by other modules. The communication is performed in such way that each module sends and receives messages based on MARS syntax.
There are four modules in METVIEW/ws that implement the core of basic needs :

- Central Module - this module assures the communication between the various modules. It is responsible for the system configuration and is able to start other module on specified workstations, when some service is required.

- General Application - this module implements the main user interface of the system. It provides the means for managing icons. It is able to create, delete, edit and start the "execution" of a definition, which may comprise the retrieval and visualisation of a data request. It can show the status of icons and display system messages.

- Data Retrieval Module - this module is responsible for data retrieval, data management and formulae evaluation.

- Visualisation Module - this module creates the physical plot windows according to their definition and performs all required plotting actions.

5. USER INTERFACE

The conceptual model used in METVIEW/ws portrays a user who selects the application best suited for a task. Within the context of the application, the user selects some data to analyze, defines how the data is to be shown and arranges the screen in a fashion which is adequate for the user's purposes. This model, therefore, distinguishes between three components of the visualisation control and lends itself to the development of an icon-driven interface which makes use of the "drag-and-drop" metaphor.

It is important that the user is able to define the arrangement of the screen. Experience with interactive visualisation in meteorology has shown that some data will be best shown in animation mode in a single window. In other cases, the user might want the screen to be partitioned into several non-overlapping windows. This would be the case when the user wants to compare the various time-steps of a forecast with the corresponding analyses.

To achieve the goals mentioned above, METVIEW/ws has three primary definitions : the Data Unit, the VisDef (visual definitions) and Plot Window/Plot Subwindow (location of plots).

The drag and drop feature has been implemented to simplify the user interface for making a visualisation request:

- A DataUnit can be dragged and dropped onto a PlotWindow.
- A VisDef icon can be dragged and dropped onto a PlotWindow if the default Visdef is not suitable.
- A DataUnit/Visdef pair can be dragged and dropped onto a Plot Subwindow.

The user will often make the next visualisation request based on previous charts, i.e. some of the PlotWindows might contain useful information to build the next visualisation request. The user can select input values for an application by pointing at an existing chart in a PlotWindow and then, optionally, modify the input values before realizing the new visualisation request.

6. DATA RETRIEVAL

One crucial aspect of any meteorological application is that of data retrieval. Often, the user needs a selection from a very large data base, which in the case of a centre such as ECMWF, spans more than 10 years. This data base may be distributed on the centre's network.

At ECMWF, the main archive is on an IBM/9000, the most recent fields are on a CRAY data base and other data bases are available on the workstation network to improve data access performance. At INPE, the physical storage of data will be different to that of ECMWF.

METVIEW/ws data retrieval service provides a transparent access to these data bases. The data bases are sequentially searched until the requested data is found.

The implementation and the configuration of this service is site dependent, because the data bases may have different programming interfaces and each centre may have its own data archival strategy.

7. DATA MANIPULATION AND APPLICATIONS

The development of applications will be oriented towards the needs and requirements of the research scientist and the operational meteorological analyst. METVIEW/ws provides a framework within which applications relating to data processing can be integrated into the system. The distributed processing protocol enables METVIEW/ws to encompass a large number of applications, which are needed for a general meteorological system.

The basic data manipulation tool comprises mathematical computations on fields. These computations are expressed by formulae, where the user is able to define arithmetic and boolean operations on DataUnits. Other mathematical functions, like max, min, mean, log, sqrt are also available.

8. THE METVIEW/ws PROJECT

METVIEW/ws is a cooperative project between ECMWF and INPE. Currently, ECMWF is also assisted by a staff member from Météo France.

METVIEW/ws is based on the ECMWF MAGICS package (Daabeck et al, 1989) and will use image processing functions from MicroMAGICS (Daabeck, 1990).

The system is being implemented using C and C++ languages.

The current status of the project is that the visualisation of images, observations and fields has been implemented, as well as the basic communication between applications and the data retrieval and manipulation module.

Specific applications have been under development during the second half of 1993. Computation of derived parameters, like relative humidity, and generation of a vertical cross-sectional plot of a field are the first specific applications to be included in METVIEW/ws. A test version of METVIEW/ws is to be provided to ECMWF users at the beginning of 1994.

9. CONCLUSION

The METVIEW/ws concept provides a standard framework within which applications relating to the retrieval, processing and visualisation of meteorological data can be easily implemented.

The use of a distributed approach is seen as a major trend in the development of complex graphic systems which deal with data in various formats.

The additional complexities in the design and programming of distributed systems are to be balanced with the needs of assuring system evolution and expansion. We hope to have achieved such a balance in METVIEW/ws, but only further experience will serve as a success indicator.

10. ACKNOWLEDGMENTS

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