SCRIBE 3.0 A PRODUCT GENERATOR

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1. INTRODUCTION

The Canadian Meteorological Centre has developed SCRIBE, an interactive expert system for composition of meteorological forecast products from weather element matrices available at an ensemble of stations or sample points (Verret et al, 1995). The matrices are produced at approximately 600 points across Canada and include statistical and direct model output parameters at a 3-h time resolution. Upon reception of the matrices, the SCRIBE Knowledge Base System processes the data to extract the events or meteorological concepts that are the results of a semantic numerical analysis of the weather element matrices content. The concepts can be displayed on a graphical user interface for editing if needed and then the Knowledge Base Systems is called once more to generate various forecast products such as public, marine, agricultural, fire weather, precipitation amounts and others. It is possible to generate from the same database a multitude of products tailored to the needs of specific clients under a variety of formats. SCRIBE has been installed at most Regional Weather Centres across Canada, where it is used operationally at various degree.

SCRIBE 3.0, a Product Generator, is based on the same approach and has been designed to have an improved flexibility, to be easier to maintain, and to give to the users the capabilities of defining the desired products, generating, managing and modifying them on site and as needed without relying on experts. The major components of the system will be briefly discussed in the following paragraphs.

2. GENERAL FRAMEWORK

Figure 1 describes the general framework within which the Product Generator has been designed. The dashed boxes and arrows in figure 1 are the components that are not available yet in the system. Numerical model output parameters and statistical weather element guidance remain the main sources of forecast information in the system. They are disseminated to the Regional Weather Centres in matrix format. Two sets of matrices are generated at each production run (00 and 12 UTC), one based on the Canadian Regional model (operational version in September 1996 : 35 km horizontal resolution, 28 levels in the vertical) (Staniforth and Mailhot, 1988) covering the forecast range from 0- to 48-h and one based on the Canadian Global model (operational version in September 1996 : spectral, triangular truncation at 199 waves, 21 levels in the vertical) (Béland and Beaudoin, 1985) for the forecast range from 0- to 72-h. A description of the statistical weather element guidance included in the matrices can be found in Verret (1992) and in Verret and Yacowar (1992). A data reduction process is applied on the weather element matrices when the data is combined in time and space following Miller and Glahn (1985) approach, before generating the concepts that are displayed on the graphical user interface for editing if needed. Once this task is accomplished the modified concepts constitute the main forecast data which is available to the Product Generator to generate the whole suite of forecast products tailored to the client needs, including graphical products. The system is designed with the capability to include the observations as input to the Knowledge Base System generating the concepts to ensure consistent meshing of the forecast parameters with the current weather. This is needed to take into consideration the most recent hourly and special observations available between the time the numerical guidance is generated and disseminated and the time the forecast products are generated. This constitutes the main trunk of the system.

The Knowledge Base System is used both at the concept generation and the product generation stages. The three major functional constituents of the Knowledge Base System are the compiler to compile the rules, the inference engine to query the rules and the fact database management system. The latter two components work together to extract and manipulate the concepts embedded in the raw data, based on knowledge represented by an ensemble of rules and to solve the truth system particular to each meteorological situation.

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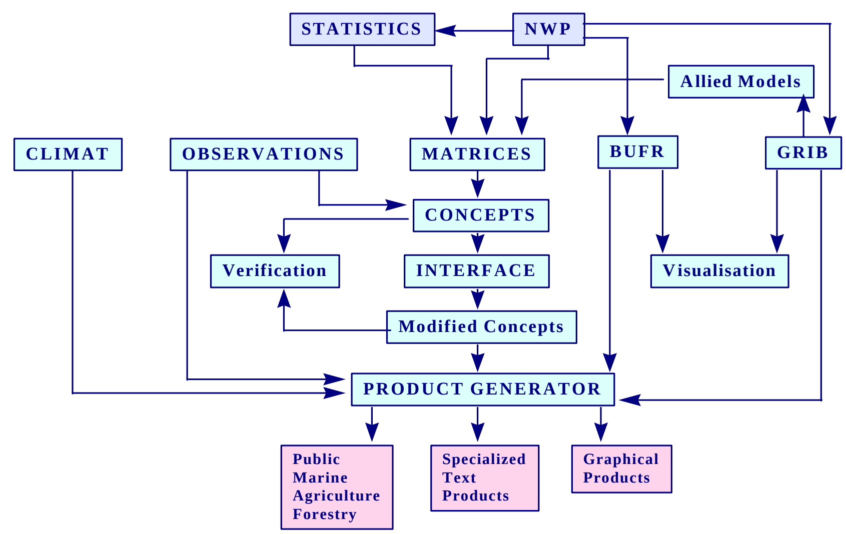

Figure 1 : Framework within which the Product Generator has been designed.

The compiler is used only once when the rules are modified or updated. Approximately 600 rules constitute the knowledge base used to generate the concepts, and over 1200 rules constitute the knowledge base for generating various final forecast products.

The Product Generator is designed to have access to other databases such as climate and observation databases to increase the range of products that can be generated. It is also designed to have access to the model forecast vertical soundings at stations in BUFR format and model fields in GRIB format that are available at the Regional Weather Centres and that can be displayed on several visualization tools. The model fields can be used to drive allied models such as sea state or surface wind models. It will be possible at a later stage to feed the outputs of those models back into the system.

A verification system has been designed to verify the objective and modified concepts that are used to generate the forecast products (Babin et al, 1995 ; Verret et al, 1996), thus giving the capability of measuring the value added to the objective guidance. Although the verification system is still under development, it can generate verification results for the forecasts of maximum/minimum temperatures, probabilities of precipitation, precipitation types and amounts, cloud cover, wind speed and direction. An interface will have to be developed to give the capabilities of generating verification results on site and as needed.

3. PRODUCT GENERATOR

The Product Generator is characterized by a functional approach that maximizes flexibility. Figure 2 gives an overview of the system. The main component is the Blackboard which controls the generation of the products. The role of the Blackboard is to interpret the specifications describing the products to be generated that are included in Product Description Files (PDF). In order to get the data needed for the product generation, it issues requests to the relational Database Management System (DBMS) that has been developed to manage the static data and also issues objectives to the Knowledge Base System (KBS) which works on the dynamic meteorological data in the concepts file. The results of the activities accomplished by the DBMS and the KBS constitute the virtual facts. Once all the needed data has been prepared and is available in the virtual facts, the Blackboard assembles the data, generates the products in the format specified in the PDF, and prepares the final outputs which in turn can be fed into external scripts or programs.

The PDF's are simple text files that are under the complete control of the system manager. They provide to the Blackboard all the necessary instructions to accomplish the tasks of product generation such as the header/title of the products, format specifications and

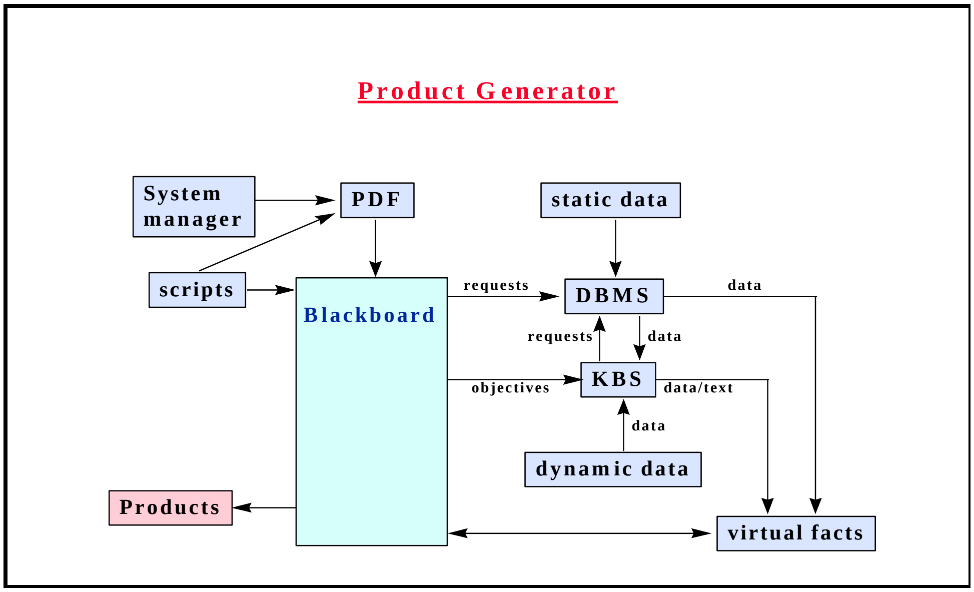

Figure 2 : Overview of the Product Generator.

the list of objectives that the Knowledge Base System must fulfill. The Blackboard can accomplish a limited amount of formatting, such as justification, indentation, upper and lower case, and table generation as specified in the PDF's, but it is possible to feed the outputs of the Blackboard to other commercial software applications, such as text editors, for more sophisticated and complete formatting and/or graphical packaging. External UNIX scripts can be included in the PDF's to be executed by the Blackboard, the results of which can be included in the products being generated.

The objectives are the goals that the KBS must achieve to generate a particular forecast product and the results of the KBS work is returned to the Blackboard in the virtual facts. An objective could be for example the clouds and weather part of a regular public forecast bulletin in plain language (not including the wind or temperature), or the surface temperature and relative humidity at noon local time. The results of the objectives can be in textual and/or numerical formats. The objectives make the KBS more modular and flexible, giving the capability of generating a specified result without having to go through the complete knowledge base. A complete redesign of the KBS had to be done which imposed a significant effort of optimization to compensate for the over-head inherent with the higher level of flexibility.

The DBMS takes care of all static data, which is the data that does not change at each production run such as product issue time, geographical area covered by a particular product or the title of the issuing Regional Weather Centre etc. Dynamic meteorological data such as the weather element matrices and the concepts are not included DBMS for efficiency. They are directly accessible by the KBS in text files. System Query Language (SQL) is used to issue requests to the DBMS and a graphical interface is available to the system manager to input new data and to modify or delete existing data. A relational model schema had to be developed for the static data. Figure 3 shows a small portion of the complete model used in the DBMS. Figure 3 says that a Regional Weather Centre which has its own area of responsibility, issues a set of products with specific product codes and types. These products may be issued several times each day and during specific periods throughout the year defined with a beginning and ending date. The products are described in Product Description Files with specific names. They are issued for specific zones, at specific times and the time periods covered in the forecast products depend on the issue time. The underlined text in figure 3 designates the search keys.

4. ASSIMILATION OF OBSERVATIONS

Work has begun to update the objective concept file with real time observations to make use of the latest observations collected between the time the guidance is prepared and the time the forecast products are generated. Figure 4 gives an overview of the approach taken. The dashed boxes and arrows in figure 4 are the modules that will become available at a later stage. The first 15- to 18-h portion of the matrices which have a 3-h time resolution is interpolated to a 1-h time resolution.

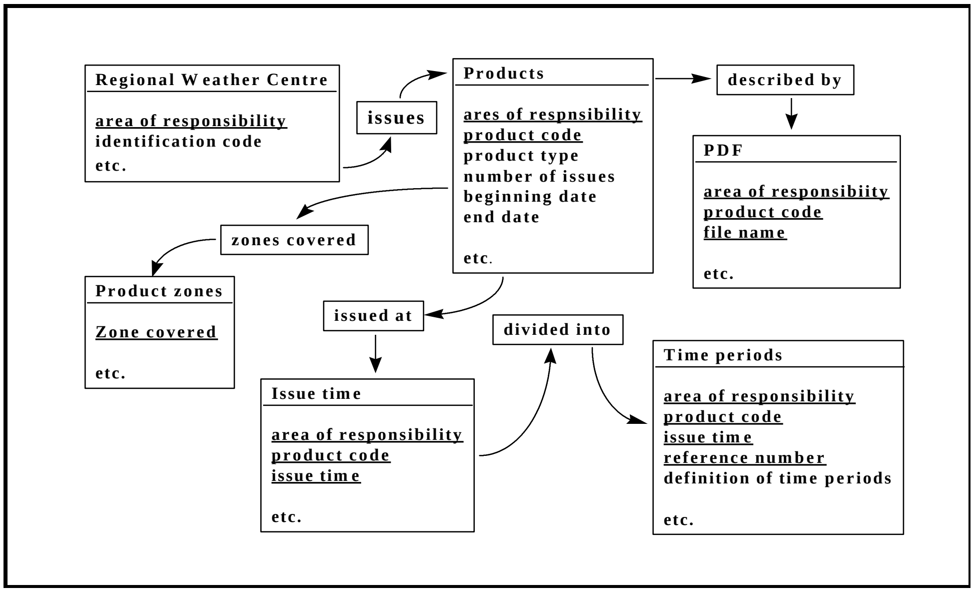

Figure 3 : Small portion of the relational model schema used for the static data in the relational Database Management System.

Observations are then used to update the interpolated matrices. A relaxation module will have to be developed to do the projection of the latest observations into the next few hours to ensure a proper meshing of the forecast with the observations. The system is designed such that the capabilities will be there to ingest radar and satellite data into the matrices, through a nowcasting system.

The updated matrices will be fed into the Knowledge Base System to generate updated concepts, which will then be blended with the original ones. The blended concepts will be displayed on the graphical user interface for editing and then become the main input to the Product Generator.

5. CONCLUSIONS

The development of the Product Generator has necessitated a complete redesign of SCRIBE. The Knowledge Base System had to be rewritten and the knowledge engineered differently to increase the

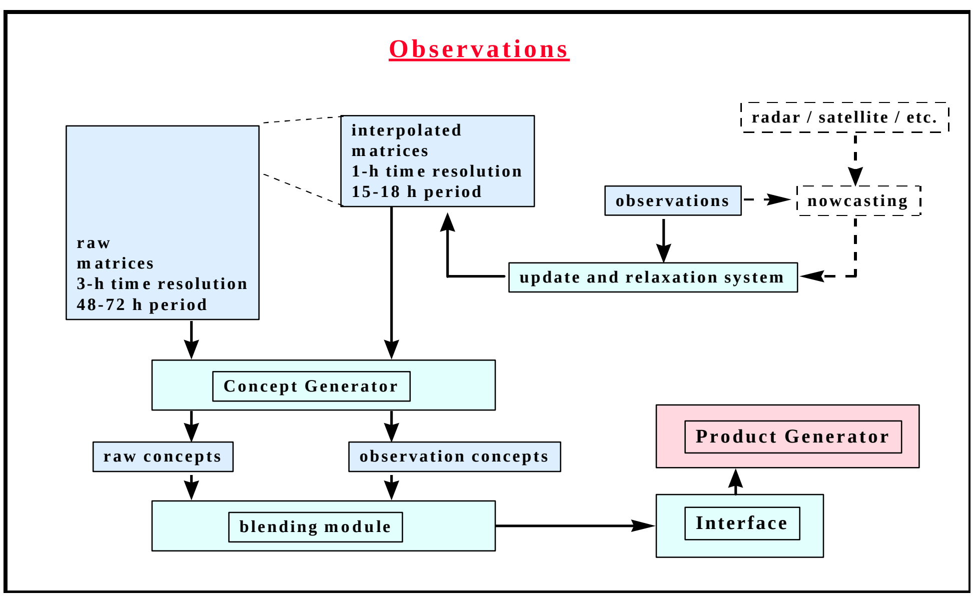

Figure 4 : Overview of the structure to ingest observations into the Product Generator.

modularity and flexibility of the system. A relational Database Management System has been developed for the static data to increase maintenance efficiency. Effort is also devoted to merge the latest observations into the system.

The next step will be to develop additional links so that the Product generator can access all available databases and particularly to increase the graphical application capabilities. It is also planned to extend the forecast period covered by the system from 72 hours to 144 hours based on Global model data.

6. ACKNOWLEDGEMENT

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