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COMPRESSION AND RELAY MANAGEMENT SYSTEM AS APPLIED TO GRIDDED FX-NET, AND AN UPDATE ON WAVELET COMPRESSION

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1. INTRODUCTION

The Compression and Relay Management System (CRMS), combined with wavelet compression as part of the Gridded FX-Net system, has become an integral tool for the National Interagency Fire Center (NIFC) and Geographical Area Coordination Center (GACC) Predictive Services forecasters in support of numerous fire weather programs and operations.

The CRMS is the enabling technology for the Gridded FX-Net system. The Gridded FX-Net system is an extended version of the National Weather Services' AWIPS (Advanced Weather Interactive Processing System), providing remote, distributed, users with access to NOAAPort and LDM data utilizing the AWIPS D2D interface. CRMS is a powerful and extremely configurable system which can take advantage of different compression techniques or transfer technologies to deliver complete grid and image datasets to remote locations.

CRMS uses the latest wavelet compression technology developed by the Earth System Research Laboratory (ESRL). The wavelet compression algorithms have been improved to reduce gridded data transmission bandwidth needed and lower memory requirements. By using this wavelet compression technology CRMS allows access to an almost complete set of NOAAPORT data through a Local Area Network (LAN), without the need for a local NOAAPORT ground station. The Gridded FX-Net system also includes various tools to extract and manipulate data from grids for use in specialized algorithms, web applications and GIS display tools.

2. CRMS OPERATIONAL USE

Since the winter of 2005, the National Interagency Fire Center (NIFC) and Geographical Area Coordination Centers (GACCs) have been using CRMS operationally to support Bureau of Land Management (BLM) and Forest Service (FS) fire weather programs. CRMS and Gridded FX-Net allow meteorologist to create daily and weekly weather outlooks for resource management and spot forecasts for prescribed burns. Currently servers are run at the Earth System Research Laboratory (ESRL) and 14 clients have been operationally deployed. Since the initial deployment, several GACC offices have requested additional client machines. The CRMS clients use the D-2D client of the Advanced Weather Interactive Processing System (AWIPS), Bullock (1994), to view and interact with the data. CRMS is currently sending an almost complete set of AWIPS data to these remote field offices, including satellite, radar, model, and METAR observations. Typical bandwidth required for all this data averages 50 MB/hour.

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3. CRMS UPDATE

Several improvements have been made to the Compression and Relay Management System, Stewart (2006.), including the implementation of a state machine to better manage data, the addition of rule based plugins, and development of a data extraction tool allowing command operation on and easy access to gridded data sets

Handler	***Function***
No Inventory Handler	Determines when data is ready to be processed
Inventory Ready	Determines which compression techniques loaded will be used and performs compression
Currently Compressing	Monitors compression of data
Compression Complete	Determines whether compression's where successful and which transfer techniques loaded will be used and performs transfers
Currently Transferring	Monitors the transferring of data
Transfer Complete	Determines if the transfer of data was successful
End Of Life	Cleans up system resources used for this particular set of data

Table 1: Sample Handlers and Functions

3.1 State Machine Implementation

The main engine of CRMS is broken into several different handlers to create state machine. Each individual state handler is responsible only for data in a specific state and are unaware of other handlers within the system. A sample list of handler's and there functions are available in **Table 1**. Based on the operation itself and the resulting outcome, the handler updates the state of a data object moving data through the system. Each handler can change the state of a data object to any other state available in the system. In addition to regular handlers, there are several error handlers available to reattempt processing data depending upon the state and the error received.

3.2 Rule Based Plugins

To keep the CRMS adaptable to additional compression or transfer technologies, CRMS upon startup will load plugin modules from a predefined directory of various compression and transfer. By using a plugin type system, additional methods can be added without modifying the base engine. Each plugin loaded acts independently of other loaded plugins for the particular compression or data transfer category, allowing the system to compress or transfer the same data in multiple ways. Each plugin must implement an Application Programmers Interface (API) to receive information from the CRMS and provide a rule set defining what data it will compress. The rule set allows the plugin developer to specify what types of data, and the parameters to use for their compression or transfer. The rule set also allows the use of wild cards to broadly define data of interest. For example, a GZip compression plugin can specify to compress any and all data, or another rule set can state, using the wavelet error tolerance compression to compress specifically the temperature variable for the GFS 40 KM dataset with a maximum error tolerance of 0.125 degrees Kelvin.

3.3. Grid Extraction Tool (GET) and custom data requests

The Gridded FX-Net system, in addition to providing fire weather forecasters with an AWIPS D2D client, creates a local AWIPS gridded model output data base. Gridded forecast fields are essential to the NIFC Predictive Services Program fire potential algorithms and disseminated guidance products. To help facilitate using gridded data in other tools, a Grid Extraction Tool (GET) was developed. The GET is a java application developed using the Apache CXF framework available from http://cxf.apache.org/. This framework allowed rapid development of a web service and provides an independent web server allowing a local server providing access the data on the client machine. The GET was developed as a web service which can be accessed from the command line or via a web service. A web interface has also been developed to allow browser based interaction with the application.

The web service is dynamic and provides variable and inventory information on demand based on data available. The GET extracts data from gridded data sets by allowing the user to specify and area of interest (lower left and upper right latitude and longitude) and a series of rules and operations to perform on data from a selected source. Multiple rules are can be created before the request is submitted. Once the rule set is formed, the request can be submitted directly to the web service or it can be saved and called programmatically allow users to perform daily calculations. NIFC fire weather forecasters use this tool to update daily web graphics and calculated fire weather indices.

Each rule within the rule set defines the variable, the units wanted, an operation, and the time or time span needed. The GET currently provides basic operations which can be applied to data during extraction. These operations range from extracting the raw point values of a variable to calculating the average, maximum, and minimum values over a time span. During the request, the request operation is performed, and if necessary and units are converted.

4. WAVELET COMPRESSION

The main compression technology in use within CRMS is the wavelet compression algorithm developed by the Earth System Research Laboratory/Global Systems Division (ESRL/GSD), Wang (2002). This algorithm has been recently improved to best utilize computing and storage power. The wavelet transform and quantization are done in an "in-place" fashion to save the memory usage. The tree structures and quantization significance map are computed and reused when it is possible to avoid recomputation. To effectively compress the data fields that contain areas of missing or incomplete data (meteorological fields at low theta levels, for example), we added a pair of new pre- and post-process procedures to our codec. The pre-process procedure includes the methods that detect and gather the shapes of the missing areas and the methods using vector or run-length schemes to encode these areas.

The new pre-process procedure first encodes the area of the missing data in an appropriate scheme, then changes these missing data points to the values that make the whole data field smooth and easy to compress. After the data fields are decoded, the post-process procedure reconstructs the missing data areas, and recovers the missing data values for these data points within the areas. The pre- and post-process procedures takes a small amount of memory and CPU time to run, and help to achieve good compression for the wavelet codec.

5. FUTURE PLANS

One major area of future development is to enhance the GET to provide more complex operations for data extraction allowing greater control over data. This will include the capability to use multiple variables in operations allowing users to implement or develop their own algorithms within the GET to improve their forecasts or decision support.

Wavelet compression will continue to evolve as new quantization and compression algorithms are investigated and improved to continue providing high fidelity data over low bandwidth lines without requiring significant resources for encoding and decoding.

6. REFERENCES

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