NATIONAL HYDROGRAPHY DATASET (NHD) CONVERSION TO ARC HYDRO: LESSONS LEARNED

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Abstract. The University of Georgia will complete the National Hydrography Dataset for the State of Georgia by the end of the 2003 calendar year. The next stage in the maturation of Georgia's water resources database is the conversion to Arc Hydro – An ArcGIS data model for water resources. This geodatabase based capability enables a behavioral approach to data modeling that enables a paradigm maturation beyond the comprehensive integration needed for a hydrologic information system to potentially enabling real-time modeling in the GIS context. The full capabilities of Arc Hydro are being realized using ArcGIS 8.3 with geodatabase dynamic segmentation functions necessary for stream networking. This implementation of Arc Hydro represents the foundation for the eventual construction of a comprehensive, integrated, real-time, environmental modeling capability for the State of Georgia.

INTRODUCTION

The National Hydrography Dataset (NHD) for Georgia constitutes a combination of the latest stream and lake databases, the 1:12,000 lake database and the 1:24,000 stream database, with improved documentation. The University of Georgia helped the United States Geologic Survey (USGS) develop these improved standards for this Geographic Information System (GIS) database and is enabling Georgia to be one of the first States in the United States to achieve this database upgrade. The NHD digitally reproduces all the hydrographic features on USGS topographic maps.

Maidment (2002) reports that Texas' environment in the past several years has been subjected to a combination of some of the greatest floods and droughts in its history – the loss of life and property mounting to billions of dollars in damages for both weather extremes. The Center for Research in Water Resources at the University of Texas at Austin, in cooperation with the Environmental Systems Research Institute (ESRI), was charged with the responsibility of developing the capability to assess how much water is still available in a drought and to predict flood conditions in time to minimize the loss of life and property. Arc Hydro, the result of this effort, is designed to be robust enough to handle even the extremes of hazardous water resources problems across small to large geographic areas. The USGS and its partners are developing a customized version of the Arc Hydro data model in which to publish the NHD.

Georgia has similarly experienced catastrophic floods and droughts during this time period. These and other complex environmental concerns have motivated the Georgia Department of Natural Resources (DNR) to strive to develop an integrated environmental modeling capability to support planning, management and disaster response. Implementation of Arc Hydro represents a foundational step in this direction. DNR's Water Resources Branch is converting the NHD database to the new Arc Hydro database standard. Arc Hydro's framework is also flexible enough to incorporate the rest of Georgia's environmental concerns. ArcGIS' geodatabase was used to construct the framework for Arc Hydro.

THE GEODATABASE FRAMEWORK

The geodatabase design has become the new paradigm for database construction because our modern society generates new information at a seemingly exponential rate and expects us at the same time to function as a globally integrated world. Traditional database design packs all the information about a group of items in a single table with many columns for each attribute. Relational database design breaks up the attribute information for each item into multiple tables. Only the attributes necessary for a particular analysis are processed, not the entire set of attributes for an item. Computer hardware designs are improving by providing us faster and multiple processors with parallel computing designs to speed the analysis of greater and greater amounts of interrelated information. Relational Database design takes advantage of multiple processor computing, and at the same time is capable of

handling the increasing amount of data without slowing processing speeds.

A geodatabase is basically a Relational Database that stores geographic coordinates and other information about geospatial objects. Latitude, longitude and altitude geographic coordinates give the geodatabase the spatial structure to build a three-dimensional mathematical matrix. Addition of multiple elements of time attribution to the geodatabase would enable the building of a temporal dimension. The items in a geodatabase are called objects. The item's attributes are the object's properties. Incorporating behavior between the objects in the geodatabase is accomplished by attaching mathematical formulas in the form of program code to the objects. This enables an object to have relationships with all surrounding objects. The object's interface, the protocol for passing information to and from the object, is the most important of the programmable behaviors.

THE NHD TO ARC HYDRO CONVERSION

The Arc Hydro data model was designed to directly support the functional requirements of both cartography and water resources modeling. Arc Hydro is not a dataset itself, but is rather an application built on top of the geodatabase to integrate and model water resources. USGS intends to keep the geodatabase version of NHD compatible with Arc Hydro so that it can be used as a source dataset to Arc Hydro. So far, they have not encountered any major disconnects because Arc Hydro was designed to be able to use the geodatabase version of NHD. USGS plans a mid-summer release of the geodatabase version of NHD.

USGS is keeping the basic content of the NHD the same in the conversion from Arc coverages to geodatabase. Several changes were incorporated into the NHD geodatabase implementation. The changes are designed to both simplify the data, the measures, and to take advantage of the new capabilities in the geodatabase environment, such as the ESRI geometric network. Flow connectivity will be built from the flow connections of the geometric network and the value of the FlowDir attribute. The FlowDir attribute captures whether or not a feature participates in flow navigation and the direction of the flow relative to the order of the coordinates in the geometry. The geodatabase implementation will be a mixture of data resolutions. Higher resolution data will be used to replace or update the existing NHD data rather than be loaded into a separate layer. Also, the geodatabase structure enables metadata to be stored in the database with the feature data rather than separately as was the case with the Arc Coverage formats.

Georgia's implementation of Arc Hydro will closely shadow these developments. The translation to geodatabase will not be completed until after the Arc coverage form of the NHD is processed by USGS, which is expected to be around the end of 2003. The availability of ArcGIS 8.3 which includes dynamic segmentation, i.e. networking, capabilities means that only ArcGIS Desktop would be necessary to fully utilize the capabilities in the geodatabase version of NHD. The subsequent building of the Arc Hydro data model involves several steps whereby the mathematical relationships between the components of the geodatabase version of NHD are built before the new model can be utilized. This requires a completely connected geometric network. Robayo (2002) describes this process in detail. Time series data, such as stream flow data, can be incorporated to build a temporal dimension for this application.

FUTURE ENVIRONMENTAL GIS IN GEORGIA

The Center For Research In Water Resources at the University of Texas in Austin is currently expanding the capabilities of Arc Hydro to integrate surface water and ground water. From this point they will likely expand Arc Hydro to be able to handle Total Maximum Daily Load (TMDL) studies. These TMDL studies involve some integration of air and soil conditions. The geodatabase foundation for these efforts has almost infinite flexibility. Eventually a comprehensive, integrated environmental modeling capability will evolve out of these, and complementary, efforts that fully harness the ArcGIS geodatabase design for environmental modeling. Georgia will certainly strive to incorporate these capabilities into our environmental practices as they emerge.

DNR / EPD has an interest in expanding integrated environmental modeling capabilities to include terraforming, essentially the capability to model corrective environmental practices. Central to these capabilities would be an epidemiological mindset that facilitates scientific investigation. A component of these capabilities would be expanding the use of geostatistics for environmental modeling. Use of the remote sensing GIS software, Imagine, will likely be incorporated in order to fully harness the expert system capabilities inherent within. Also, the Georgia Tech GIS Center's state-of-the-art global virtual GIS

capability could be harnessed as a visualization and modeling tool. Their Virtual Earth modeling capability is useful for local to global visualization, and the development / testing of vector GIS models.

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