GRASSCLIPPINGS

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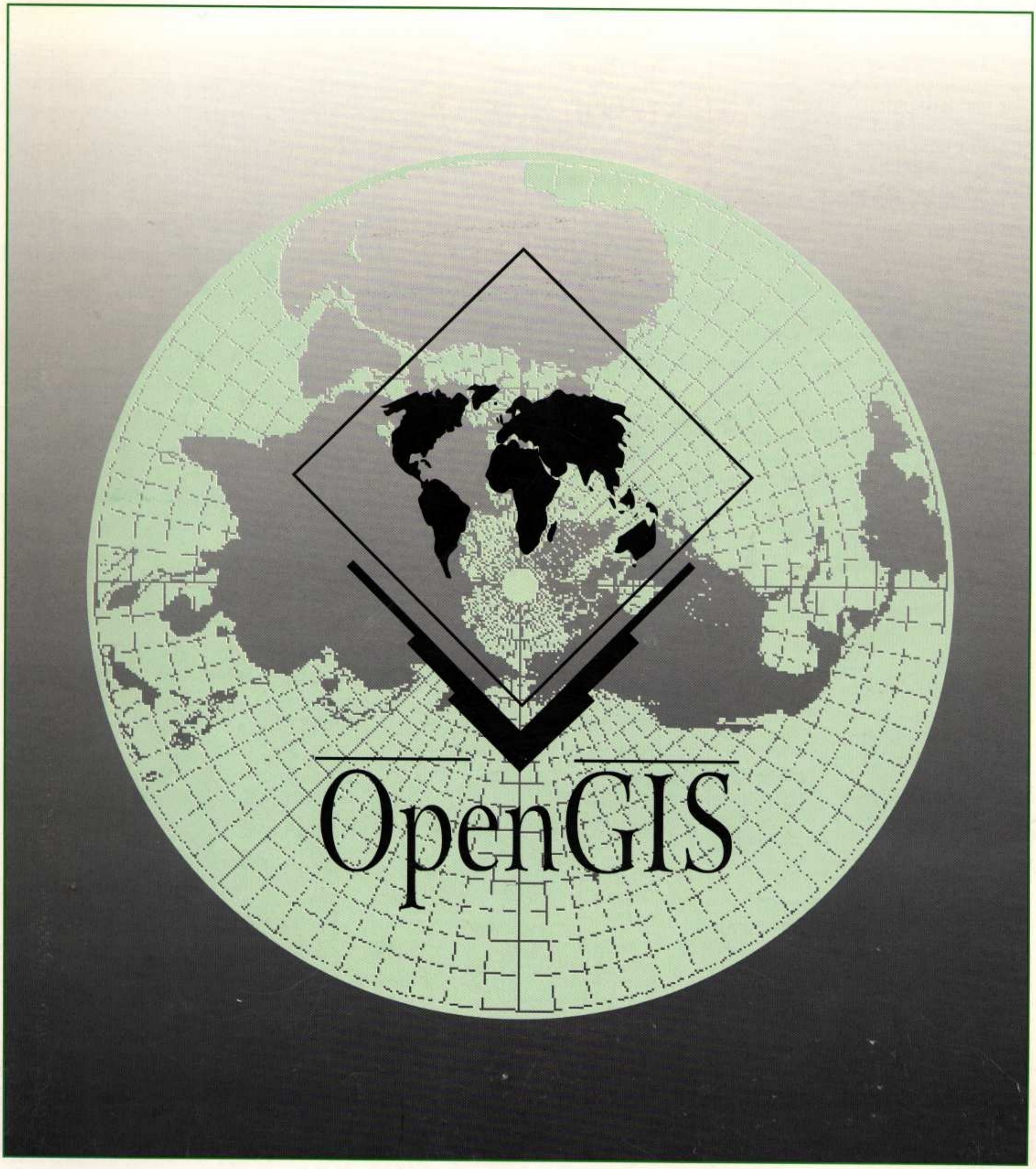

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DEPARTMENTS

FEATURES

COLUMNS

Crouse Printing and Mailing, Champaign, Illinois, has been printing GRASSCLIPPINGS since 1989. OGF's Executive Director and Board of Directors wish to thank Shirley and David Crouse and their employees for their unfailing support, advice, and patience, and for the dependable high quality of their work.

The Open GIS Foundation

A Forum for the Promotion of Open Geographic Information Systems

The Open GRASS Foundation has changed its name to The Open GIS Foundation to reflect a broader focus and to express the organization's desire to emphasize GRASS in the context of the larger concerns of "Open GIS" and "interoperability".

This change does not indicate a deemphasis of GRASS — OGF is by definition dedicated to the promotion and support of GRASS technology, as well as to the continual evolution of GRASS with respect to modern computing paradigms! OGF continues to work closely with the Office of GRASS Integration at USACERL to ensure that a GRASS release is readily available to the GIS community and to maximize the flow of information about GRASS and GRASS applications to both public and private sector organizations.

The primary reason for OGF's name change is the increasing amount of work we have been doing to develop and organize support for the Open Geodata Interoperability Specification (OGIS), a software approach to simplifying application program access to heterogeneous geographic databases. OGF has been working on interoperability, or "Open GIS", issues since its inception in June 1992, in conjunction with both USACERL and several of OGF's sponsoring members. With leadership and resources drawn from these organizations, as well as from the OGF Board of Directors, OGF has recently established a technology working group to define and document the OGIS, and has organized a "consensus process" designed to ensure that the OGIS reflects the combined interests of significant government, academic and commercial organizations active in the geoprocessing community.

As a non-profit corporation focused on the development of affordable GIS resources for both the public and private sectors, the Open GIS Foundation welcomed this opportunity to assist directly in accomplishing the agenda of the National Information Infrastructure (NII). By defining the OGIS, OGF is taking a significant step toward addressing the requirement for real time integration of heterogeneous geographical databases using a uniform application interface. Along with meaningful geodata transfer standards, there may be no more important issue to face in dealing with the critical problems of geographical data distribution, large scale GIS application development, and the implementation of distributed decision support systems which require large amounts of geographically based data drawn from a variety of sources.

The OGIS Project was organized in June 1993 as a series of monthly technology development and management review meetings positioned to be the basis for evolving a funded consortium to formalize and promote the OGIS as an interoperability standard for the geoprocessing community. With the last OGIS Project Review Meeting on September 22 in Denver, it became apparent that the OGIS Project had achieved the level of participation needed to indicate its technology potential, as well as its implications for the ongoing work of major standards organizations concerned with the NII. At this point OGF began actively seeking commercial support to make such a consortium a reality.

In changing our name to "The Open GIS Foundation", we are emphasizing our commitment to identifying and promoting the basic platform technologies that define and drive the concept of "Open GIS". The basic premises of OGF's work are that "data" is the most important issue in the geoprocessing community; that "public access to geodata" is of the highest value and must be facilitated; that application technology must serve the ends of wide and effective distribution of data (particularly data which is financed by the federal government); that geoprocessing application architectures must evolve with the basic operating system and communications technologies that drive the information processing industries; and, that organizations participating in the geoprocessing industry — government, academic and commercial — must work together to evolve a common data sharing architecture to best serve the needs of the nation as a whole.

OGF's fundamental position, and one that is entirely consistent with the philosophy of GRASS, is that although data standards are of great importance, they must nevertheless be considered a function of the underlying information processing technologies that drive the culture. OGF therefore emphasizes software architecture, as well as efforts within the geoprocessing community to find new and more efficient ways to combine GIS technologies with concepts of distributed processing, object oriented development methodologies, database strategies, and real time information access. OGF is concerned that the traditional monolithic approach to building GIS application environments is no longer viable given the direction of distributed system technologies in general, and its mission is defined to facilitate a technology approach that functions as a bridge between traditional software practices in GIS, and the high bandwidth, heterogeneous distributed geoprocessing environments of the future.

In this context, it is important to note the logic in OGF's evolving focus from GRASS to Open GIS. From the beginning, contrary to the views of various commercial software companies, GRASS was not actually positioned to be a "competitive GIS product". In our view, GRASS is less a commercially competitive product than an open development resource, and, as such, it is GRASS which suggested the original concept of Open GIS. GRASS provides an easily accessible programming environment with fully disclosed data formats, built to be coextensive with UNIX system resources, and free of charge to anyone who has access to the Internet. In addition, GRASS has an active community of supporters who share both development and application information, and it is used by students and researchers in more than 100 colleges and universities around the world. GRASS is often called one of the best test-bed, or prototyping environments for GIS developers — its accessible source code and ease of programming enable both students and researchers to create proof-of-concept solutions for complex projects at minimal cost, and with frequently extraordinary speed. In fact, many commercial products derive in part from work done with GRASS in universities and government laboratories, and it is therefore more fitting to emphasize the role of GRASS as "technology transfer agent", than as "competitive commercial GIS."

The OGIS project grows out of OGF's GRASS related activities in the area of software integration, or the merging of complementary software packages to create more complete and robust geoprocessing environments. Many people had already integrated other application products or tools with GRASS, or simply appropriated GRASS for use as a component of a special purpose application system, and many commercial organizations have even chosen to use GRASS as part of their privately labeled product offerings. GRASS has long been a valued resource to many people in the geoprocessing community, not only for the GIS capabilities that it represents, but also because there is a great deal of data in GRASS format. OGF began to work with such companies as PCI Remote Sensing and Statistical Sciences, both of which had already begun GRASS integration projects, and out of these relationships grew the recognition that the ability to share geographical databases in real time among such packages was an even more significant issue than working to extend software features. Early work in this area was encouraged by a grant from Sun in response to a proposal to create what we called then the "Open GIS Application Environment" (OGAE). The OGAE was based on the concept that GIS and related software organizations should disclose data formats in order to enable cost-effective integration projects, and that an integration methodology could be formalized as a series of compliance levels, depending on the desired level of integration within the context of OGAE.

OGF's technology working group was formed jointly with the Center for Advanced Spatial Technologies (CAST) at the University of Arkansas, and USACERL, and was chartered to develop a formal specification based on the OGAE. This effort was driven largely by Kenn Gardels of UC Berkeley, an OGF Director; Kurt Buehler, Chief of the Spatial Analysis and Systems Team at USACERL; and Jim Farley, Technology Director at CAST, with significant input from Marty Holko, a senior GIS technologist at the Soil Conservation Service. In the course of the first meetings, the OGAE evolved into the concept now termed the "Open Geodata Interoperability Specification", or the "OGIS", and the software strategy described above emerged as a major focus for OGF. Subsequently, the working group was joined by Intergraph and PCI Remote Sensing, both of which, along with Sun Microsystems, had offered strong encouragement for the process from the outset. At the same time OGF established a working relationship with the Object Management Group, author of the distributed object system specification, CORBA. And, as I mentioned, the most recent project review meeting demonstrated considerable interest in the OGIS concept — at this meeting OGF reported on the state of OGIS development to representatives from more than 20 private and public sector organizations active in the geoprocessing community, including, in addition to those already mentioned, MITRE, ESRI, ERDAS, Genasys II, Silicon Graphics, NASA, Booz Allen & Hamilton, and the recently created National Biological Survey.

In the following article by Kenn Gardels, the OGIS concept is spelled out with great clarity, and the opportunity to crystallize the OGIS movement into a working standards forum is well defined. We have found that most of the organizations contacted about the OGIS are wrestling with the same issues, except that each is doing so on the basis of its own proprietary technologies. We have found also that most of these organizations are ready to join a common movement involving a generalized approach and an emerging standard. In this regard, OGF has distributed a proposal to establish a consortium dedicated to formalizing the OGIS process and producing the industry's first acceptable interoperability specification. Such an organization, positioned to work with the FGDC and other high level standards organizations to address interoperability issues within the context of the NII, could have a significant impact on the rate at which the nation's wealth of geodata becomes generally available for key decision support tasks in both the public and private sectors.

OGF manages the business affairs of the GRASS community, and continues to work with the organizations that use and distribute GRASS. In particular, OGF maintains very close working relations with both USACERL and the Soil Conservation Service, the two most significant developers and users of GRASS in the federal government. In this regard, however, I would like to stress that OGF has not found its two missions to be at all inconsistent. OGF is a disinterested, non-profit corporation, primarily concerned with the promotion of open systems approaches to GIS and geodata interoperability, and its main concern remains the effective use of both software and data resources in the context of national priorities.

As GRASS grows stronger, the Open GIS movement grows stronger, and as Open GIS gains momentum, there is even greater opportunity for GRASS developers and end users alike to be part of the expanding mainstream of distributed geoprocessing technologies incorporated into the backbone of the emerging NII. It is in this spirit that we rededicate the GRASSClippings, and we look forward to working with the GRASS community, as well as with the GIS technology community at large, to promote the values of open application resources and consensus-based interoperability standards.

David Schell, Executive Director

OPEN GIS

From the Editor

No one can doubt now the original vision of the creators of GRASS. There will be an increasingly open environment for building and using GIS tools and databases, and GRASS will be at the center.

For this issue of *GRASSClippings, the Journal of Open GIS*, the expanding GRASS community has once again provided an excellent set of articles and columns. Many of the articles relate to the theme of object oriented GIS technology that is still in the planning stage, but in this issue of *GRASSClippings* we have tried to stick with our usual format. We seek to provide government, business, and academic readers with news, updates, a workshop schedule, and tips to practitioners. Many thanks to all of our contributors. We had more good articles than we could print. My sincerest apologies to those whose articles did not appear because of space limitations.

And thanks to former Associate Editor Hayes Batten, who has left OGF to devote more time to his art and architecture studies, but who agreed to help lay out this issue.

A special thanks, too, to our sponsors and advertisers, without whom we could not afford so many pages and so much color. Just think, we could offer more issues, more pages, and more color if we had more advertisers. So please, if your business stands to benefit from visibility in the Open GIS community, give us a call!

Lance McKee, Managing Editor

From OGF Operations

It's that time of year again! A call for papers has been issued for the 9th Annual GRASS GIS Users' Conference and Exhibition. You should have received an announcement containing the call for papers as well as workshop and registration information. If you did not receive the announcement, or if you would like extra copies, call the Open GIS Foundation at (617) 621-7025.

The Soil Conservation Service is sponsoring this year's conference. Their continuing support is greatly appreciated by the Open GIS Foundation, and the GRASS community in general.

Several new features have been added to the 1994 conference. There will be a series of panel discussions covering current topics such as Open GIS, Federal Activities in GIS, and application integration. There will now be two full days of workshops, allowing participation in up to four courses. New workshops have been added, thanks to your comments and suggestions. A special military applications track has been created to encourage representation from the various military installations. We are working to improve last year's expanded conference format by adding such features. We hope to make the 9th Annual GRASS Conference the best ever. But please, NO BLIZZARDS!

Pamela Cashman, Director of Operations

Defining Open GIS: An Introduction to the Open Geodata Interoperability Specification (OGIS)

by Kenn Gardels

The open systems model - exemplified in many ways by Unix - is an approach to software engineering and system design that enables and encourages sharing of data, resources, tools, and so forth, between different users or applications. The intent of Open GIS is to move away from the current paradigm in which specific GIS applications are tightly coupled to their internal data models and structures. Open GIS facilitates exchange of information not only between individual Geographical Information System (GIS) packages, but also between GIS packages and application systems based on other technologies, such as statistical analysis, image processing, document management, or visualization.

What is Open GIS?

As costs of computer hardware and software for GIS decline, resource managers are paying increasing attention to maximizing the value of environmental data. Much work to date has been done in the areas of standardized data development, distribution of digital information, and format translation. Less effort has been directed toward the exchange of information between inventory-based GIS applications and analytical tools such as statistical analysis, process modeling, and pattern recognition. Future success of GIS as a technology and as a paradigm for spatial understanding will depend on the seamless integration of diverse methods into a comprehensive system for scientific investigation and environmental planning.

The fundamental requirements of the Open GIS are as follows:

• Heterogeneous Application Environment — A user workbench that is configurable to utilize the specific tools and data necessary to solve a problem.

• Shared Data Space — A generic data model supporting a variety of analytical and cartographic applications.

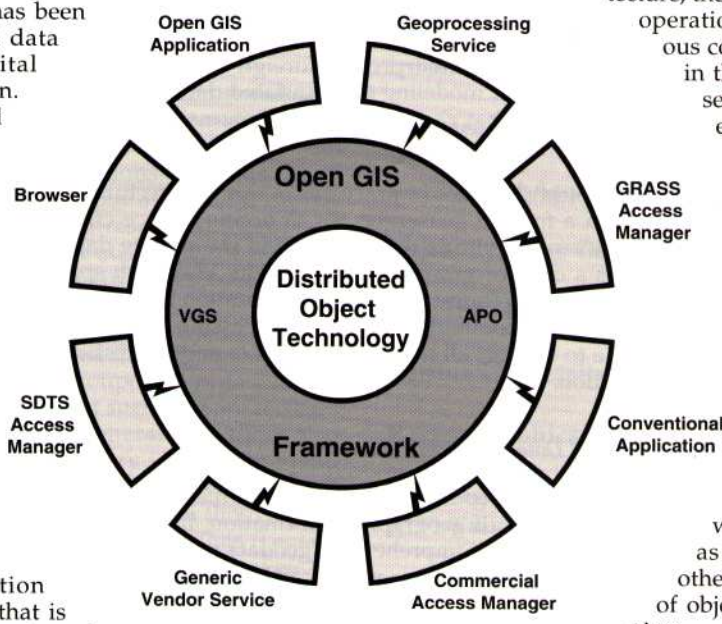
• Interoperable Resource Browser — A method for exploring and accessing the information and analytical resources available on a network.

The overall goal of Open GIS is to encourage software developers and integrators to adhere to these requirements, and through time create tools, databases, and communications systems that maximize the utility of the system and take advantage of technological advances. The Open GIS Foundation is working to organize a broad-based consortium of government agencies, research organizations, software developers, and systems integrators to engage in a multi-year effort to define Open GIS and to develop a set of requirements, standards, and specifications which support this goal.

The Architecture of Open GIS

The three broad requirements for Open GIS — heterogeneous applications, shared data space, and interoperable resource browser — are all linked in the overall system architecture. Although each is being investigated and developed as a distinct set of capabilities, they are all defined to coexist in a common framework that defines how system components interact. Of course, these components are themselves complex and will have multiple levels and modes of interaction with each other.

The Open GIS architecture is designed to provide robust methods for accessing multiple forms of data using multiple software environments. That is, any compliant GIS or other application that uses geodata should be able to access and use distributed information in any supported format. The nexus of the interaction between application and information is defined as a common data model, the Virtual Geodata Store (VGS), access using Application Programming Objects (APOs). The communication is facilitated by an object request broker architecture, such as the Object Management Group's CORBA, or another effectively similar specification. The figure on this page provides an overview of the general architecture of Open GIS, as currently envisioned. Although the construction of this figure might suggest a shell architecture, the intention is actually to diagram the operational relationships among the various components. In fact, every construct in this architecture — data, processes, servers — is in reality an object., and each such object supports specific interface methods to facilitate communication (via the object broker) with other objects. What makes this approach unique is that it calls for specialized services to be developed to provide the functionality needed for interfaces to be meaningful. For example, access managers are to provide the detailed protocols necessary to convert a private data format to the generic model of the geodata store. In fact, the figure might be redrawn with "distributed object technology" as a bus to which are connected all other functional constructs in the form of objects providing and requesting services.



Data Browsing and Access

The basic functionality to be provided by Open GIS is access to data held in multiple data formats. The objective of the Open Geodata Interoperability Specification (OGIS) project, underway since June 1993, is to design and implement methods to provide an object oriented architectural framework for access to geodata, independent of the specific data structures and file formats used to model the data. From a user's point of view, OGIS will allow access to geodata at remote locations, no matter the format. From an application developer's point of view, OGIS will provide a set of network services to identify, interpret, and represent a dataset from a geodata server to a geoprocessing client.

It is important to note that OGIS is conceived as an operational model, not a data standard. The overall premise of OGIS is a specific set of software tools for dynamically translating geodata from various sources into a single, comprehensive object based data model which can then be accessed directly from applications using a basic toolkit or primitive operations. In the context of Open Geographic Information Systems, OGIS provides the framework within which other broad categories of functionality exist, notably the virtual data store which models geodata, and the application programming objects which act as interfaces to application software and systems.

[Gardels, Continued on page 8]

[Gardels, Continued from page 7]

OGIS attempts to accomplish these operational objectives, first, using an object-oriented implementation, based on existing distributed object methods and architectures. This means that every component of the specification - be it a data format, an application, a geodata model, a converter, or a user schema - is an object and as such can be manipulated by a set of utilities designed for object management. Second, OGIS development will be phased both in a general architectural sense and in its specific prototype implementations. That is, methods will be established initially to provide simple reads of geodata, followed by write options in various formats, and finally by an incremental approach to defining and implementing geoprocessing operators. Third, OGIS development will start with well-defined, open interchange and transfer formats as a basis for geodata objects, such as SDTS. As procedures for interpreting these formats within the OGIS model become well-defined, subsequent efforts will focus on standard distribution formats and finally (in conjunction with outside system developers) private data formats.

The fundamental property of OGIS, interoperability, is determined by the plethora of existing data structures - not only must specific translations be robust and consistent, they must resolve inconsistencies between various data models. For example, OGIS must enable transparent access to both geo-relational and feature-based geodata models. Specifically, interoperability means the ability to access and translate data by means of a process of discovery and dynamic interpretation when the salient factors cannot be known in advance.

The overall architecture of OGIS is a set of client services which in turn use other object management services. This means that every entity in OGIS is an object that can be managed using non-geographic object management technology. The approach currently envisioned is to use an object request broker as the foundation for OGIS. Accessing this broker are a set of services for identifying and interpreting foreign or private geodata sources (access objects), a library, or repository for modeling the translated data representations (geodata objects), and a set of operations tools that can provide geoprocessing functionality for geodata objects (geoprocessor objects).

A typical sequence of processes in this architecture is as follows: (1) an application requests data from a foreign geoserver; (2) an access service creates an object which manages the interface between the virtual data model and the private data structure; (3) the access manager instantiates a class or group of classes in the VGS with specific geodata objects needed to answer the application request; and (4) the application is handed an ID which describes the specific object(s). All of this communication and processing is managed by the Object Request Broker, which is able to connect all these different data and processing objects transparently to the end user application.

Shared Data Model and Store

The Virtual Geodata Store (VGS) is at the heart of the Open GIS concept. It provides a consistent logical view of geographic information, independent of the underlying data model or format. Because it is a comprehensive geodata representation, it allows the creation of a set of high-level functions or operations which can be used by applications for accessing different data sets.

Geographic information is collected and managed for numerous purposes, each of which has its own requirements for how data are most efficiently organized, what comprises features of interest, what degree of precision and accuracy is necessary, how information is analyzed and displayed, and so on. As a result, there are now many geodata representations, which are largely incompatible and which limit their utility for a community of users. For purposes of this discussion, we define the following levels of representation of geographic information:

- Data model refers to the conceptual view of a set of information, for example map themes, discrete features and objects, observations, or numeric or algorithmic descriptions.
- Data structure refers to the method used to encode geographic information, such as arc-node (topologically related vectors), CAD, raster, database records, or linked objects.
- Data format refers to the specific protocol or procedure used to store and manage geo data, such as GRASS run-length encoding for rasters or ARC/INFO coverages for vectors.

In these definitions geographic information comprises data points or features in which every single entity can be uniquely described in terms of its physical location in space (and possibly time). It is true that there are many other forms of information that relate generally to space, such as a journal article on a place, but these types are not included in our working definition of geographic information, except as described below.

The objective of the VGS, then, is to create a single comprehensive model which embraces the range of existing models and their associated structures. That is, the VGS must be able to describe any datum held in any format developed to the parameters associated with any data model. From an application perspective, rather than from a data perspective, the VGS must provide methods by which a user can query geographic information contained in the VGS.

In terms of the overall Open GIS architecture, a query to the VGS will trigger a sequence of operations to identify an appropriate data source; to extract information from that source whatever its structure; to reformat the data as necessary; and to model the data according to the protocols of the VGS. Queries can be simple statements, such as

```
retrieve layer
```

or more complex, conditional statements, such as

```
select <feature> where <conditionA> and <conditionB>
```

High level functionality - such as analytical modeling - will continue to be provided by applications using the VGS APO. Details will be determined in part with standards organizations such as ISO, who are working concurrently on other open systems specifications, including SQL3 and its multimedia spatial extensions. Initially, the VGS must address data management requirements for commonly used geoprocessing systems and the geodata associated with them. These include not only a variety of formats and structures, but fundamentally different models for representing geographic phenomena. Thus we need to define a VGS structure from the top down that at least provides a context for divergent data types.

At a data model level, we have defined three broad realms of geographic information: feature, imagery, and field.

1.) Feature information corresponds, generally, to traditional map cartography and to the types of entities represented on maps, such as roads, landmarks, cadastre, and so forth. The feature component of the model is based on geometric descriptions of points, lines, areas, volumes, and networks, with or without a temporal expression. The VGS makes no requirement with respect to topological versus polygonal structures, tessellation or continuity of features, aggregation of similar features into maps or coverages, or any other such policy decisions.

2.) Image information is pixel or raster based data obtained from a remote sensor or analogous source, and grouped or organized by geographic location. This does not imply that such data are rectified to a coordinate system; indeed, the VGS generally assumes that image data are uncontrolled. Although imagery is typically multiband, this characteristic is intentionally not included as an intrinsic part of the model. This is because of the fact that even though most imagery today is expressed in two geographic dimensions (i.e. latitude and longitude), VGS must support 3D (block) and even 4D (animated) images. In this context then, multi- or even hyper- spectral characteristics do not constitute "dimensions" per se.

3.) Field information is numeric geodata, in which a regular or irregular set of nodes define an interpolable, continuous surface or volume in three or more dimensions. The VGS must include provisions for more advanced 3/4D modeling systems' data structures, general circulation models, real-time varying data, dynamic GPS referencing of moving entities and phenomena, etc. Field information shares many characteristics with imagery, in that there is typically a gridded representation of the information, and many of the required functions are closely related to image processing operations. Field information shares other characteristics with features, in that boundaries of phenomena - where there is a change from one value to another, for example - can be described as areas and manipulated as discrete entities. Unlike features, though, they cannot be directly deleted, moved, etc., since they only exist in relation to surrounding phenomena.

Use of an object oriented database structure and programming approach is necessary to meet the objectives of the VGS. This is true for the following reasons:

• The VGS must provide a mechanism for storing and managing data in a wide variety of formats associated with multiple data models. This cannot be accomplished using traditional database stores due to their limitations of datatypes nor can it be accomplished using typical GIS datafiles due to the lack of integration between those datafiles.

[Gardels, Continued on page 13]

[Gardels, Continued from page 9]

• The VGS must allow random access to any selected data element based on a simple description so that information retrieved from private datasets is immediately available for use without further processing. This cannot be done using most data transfer formats (such as SDTS or DLG) since geographic features are not uniquely identified or completely described.

• Associated with each type of geographic object are methods for selection, analysis, display, and combination with other objects. Object oriented systems provide this close coupling of datatypes and methods.

• It must be possible to provide persistent storage of modeled geodata for continued use without explicit intervention by the user. That is, when information is remodeled in response to a query, the resulting objects should remain in the store for later use. This cannot be done in conventional procedural programming without creating an independent file storage system, which negates the purpose of the VGS.

• The system must be fully extensible, so that new data types and methods can be accommodated without modification of the existing system.

• The VGS must manage not only geographic information as defined above, but also be able to link this with descriptive metadata, which may be explicitly derived from private data or inferred from other sources. Although conventional relational DBMSs provide ad hoc query construction, they presuppose a predefined schema for all possible data values and types; OO systems allow such relationships to be defined on an as-needed basis. There are existing classification systems that address significant portions of the VGS, and which can be adopted to its implementation. None currently provides sufficient support in all three realms concurrently, however. Perhaps more importantly, there are many ancillary datatypes that do not meet the rigorous definition of geographic information provide above. These include, but are not limited to, printed documents, audio/video, dynamic telemetered information, messaging/conferencing systems, and so forth.

Whither GRASS?

At the present time, no geoprocessing (in the most general sense) applications can make use of this architecture or the services to be provided by the OGIS and VGS. The first step to this end will be the construction of application programming objects (APOs) that enable direct access to the information modeled in the VGS. Software developers can choose to design tools and functions which use those directly, or via toolkits that provide a more conventional application programming interface (API) which in turn handles object management. (The next issue of *GRASSClippings* will address APO functionality in detail.)

Since the same systems which will generate information requests will also be managing geodatabases, and in a general sense the same services will provide translations both to and from the object model, developers can also choose the methods by which services can access private database structures. That is, a system could implement its own APO, in which case translation might involve a relatively simple "transfer" operation; in other cases, a low-level API might require an object service to first request a generalized data extraction function followed by a series of spatial processing steps to convert the data to an alternate model.

GRASS, as it currently exists, will gradually begin to incorporate both levels of compliance with the Open GIS architecture. That is, it will acquire its own APO that will allow it to transparently utilize information in the generic data model of the VGS. This means that ultimately GRASS users would have access to a broader array of geodata, and users of other systems could take advantage of specific functionality offered by GRASS.