ERDAS APOLLO 2010
Concepts Guide

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Geographic Information Data and Concepts

In this chapter:

Introduction

This guide will explain some basic technical information that you need to understand in order to completely understand what the ERDAS APOLLO system does.

How is Geographic Data Special?

Geographically referenced data (or geodata) is data that is connected to locations on the earth. That data might be based on a range of values, such as rainfall amounts or elevation above sea level, or it might deal with geographical features, such as lakes, city boundaries, land use zones, or road types. Geographical information (GI) is an attempt to put the geodata into a format that is meaningful for people but that can also be used and manipulated by computers.

GI is used by different organization such as telecommunications companies, environmental management agencies, natural disaster management agencies, and the military. It can be used to solve a wide range of problems. For example, you could use GI to:

- design and maintain a telecommunications network
- locate and control a wildfire
- design and maintain a network for water, electricity, or gas distribution
- see where homes for sale are located in relation to schools, parks, hospitals, or fire stations

- determine the best route for a family drive.

Fundamental GI Data Concepts

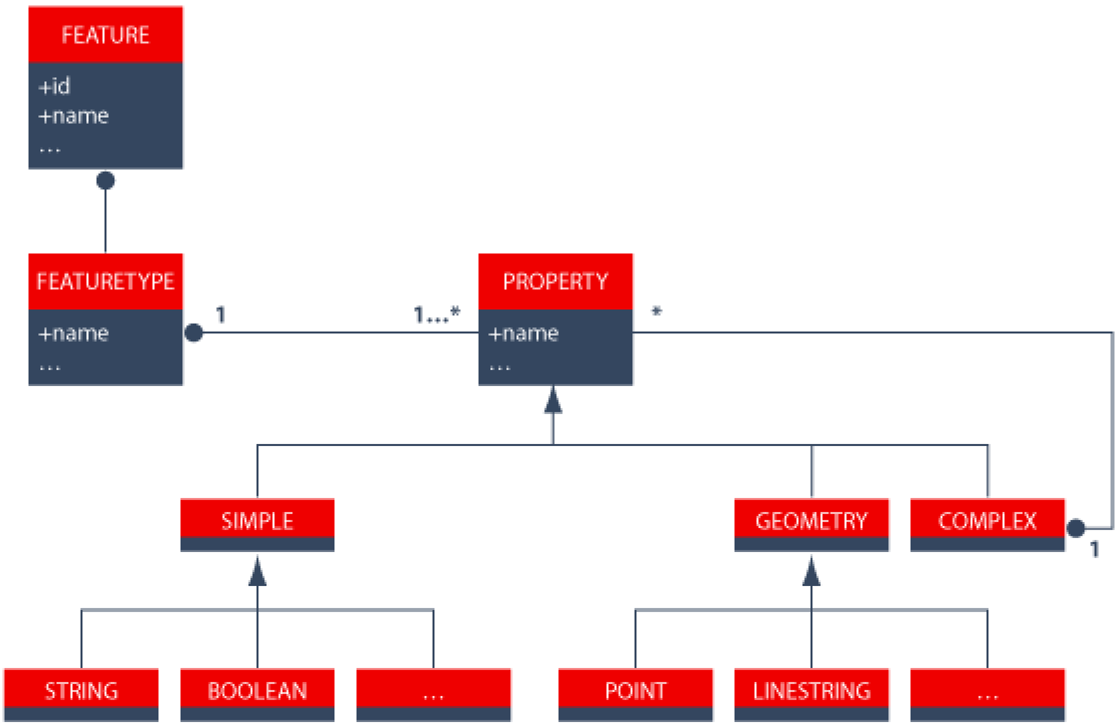
Rasters and vectors are the two basic data structures for storing and manipulating geographic information. The raster model stores data as cell values in a geo-referenced grid. The vector model represents the information using geometric and mathematical associations.

Features/Feature Types

According to the Open Geospatial Consortium (OGC): "A feature is an abstraction of a real world phenomenon; it is a *geographic* feature if it is associated with a location relative to the Earth." [1]

These features are a standard representation of vector datasets as they deal with geographic information as a set of vector information. These features are also aggregated in classes of features, called feature type. Each of these feature types represents a class of real world objects. For example, all the road features are held in a feature type called *RoadType.*

Figure 1: Features and Feature Types



The feature type presents the syntactical description of the features as a set of property definitions which can be either simple, complex, or geometric. This representation allows definition of arbitrary complex data models and provides enough constraints to allow interoperability.

The feature types also bring part of the semantic definition of the features. By sharing feature type and property definitions, communities can develop networks of geographic information.

Rasters

The raster model stores data by representing geographic information as cell values in a grid. All of the cells on the grid are identified by a unique coordinate location and a value. The raster model is particularly useful for working with continuous forms of features such as soil types or vegetation coverage.

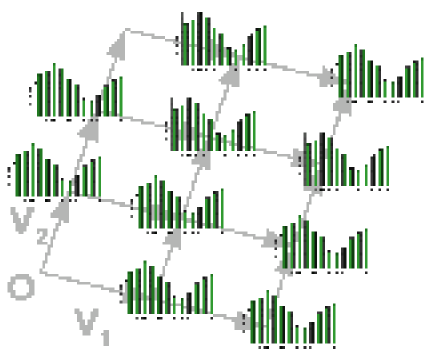
Traditional images are examples of raster images[2], but the raster concept can be extended to include more complex information such as satellite imagery and radar measurements. In this case, each raster cell is filled with a set of values where each one represents a physical property measured at the location of the cell.

Another common type of raster is the result of the portrayal process. This process transforms vector information into a raster representation. This process is described in detail in the next section.

Coverages

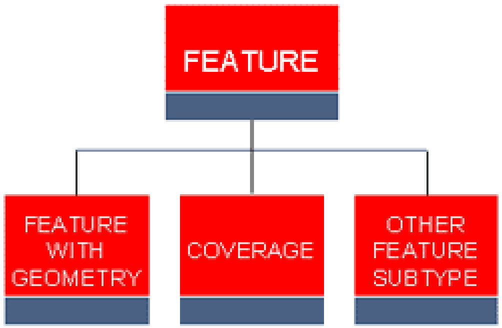
Coverages are a type of digital geospatial information comprised of regularly spaced locations along the 1, 2, or 3 axes of a spatial coordinate reference system representing space-varying phenomena. A coverage with a homogeneous range set defines, at each location in the domain, either a single (scalar) value such as elevation, or a series (array / tensor) of values all defined in the same way, such as brightness values in different parts of the electromagnetic spectrum.

Figure 2: Spectral response observable "radiance"



Coverages, which are considered to be a specialized feature type, consist of a broad category of data as they describe a set of spatial locations, instead of just one fixed phenomenon. Coverage data covers a broad range of information from soil maps (soil types of specific areas), satellite images (brightness of a set of pixels), digital elevation models (regularly-spaced elevation data, or triangulated irregular spot elevations) to grid coverages (whose domain consists of a rectangular array of points, cells, or pixels and are especially important for earth observation data, such as aerial or satellite imagery).

Figure 3: Coverage as a Feature Subtype



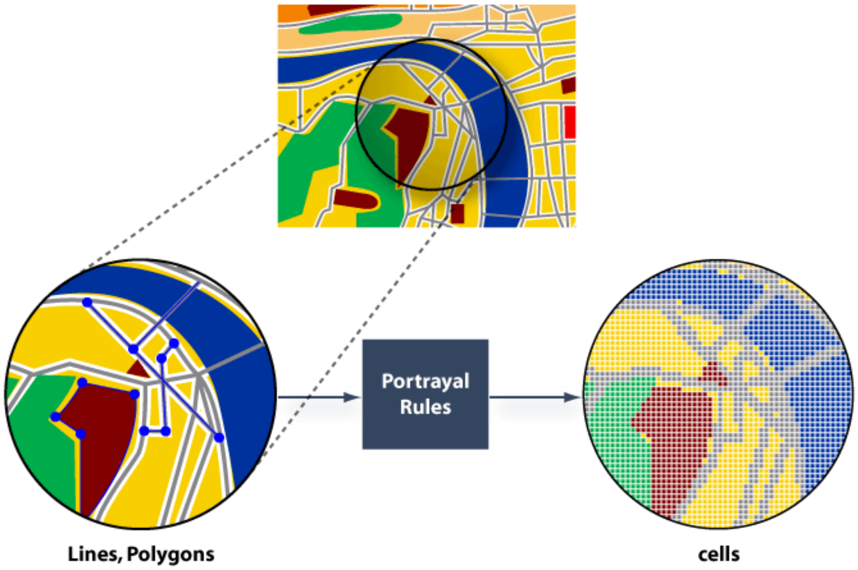
Fundamentally, coverages (and images) provide humans with a multidimensional “view” of an area with geographic features. We define a "view" as a visual representation of geodata; a view is not the data itself. ERDAS APOLLO sets this “view” to be geospatially registered to the Earth.

Coverages are published in an OGC Web Coverage Service as intact (raw) information. Coverages can then be requested by a client and sent to a Coverage Portrayal Service (a component created by ERDAS APOLLO) to be rendered in SLD and returned back to the requestor in a usable format. For more information about the Web Coverage Service and the Coverage Portrayal Service, see **Catalogue Service for the Web (CSW)** on page 22.

Portrayal and Layers

The portrayal process transforms geographic information into a form easily understandable by humans. A common example is the transformation of vector-based information into a raster representation of this information. This transformation is specified by a set of rules applied to the input data sets. This process improves the use of geographic information for decision making.

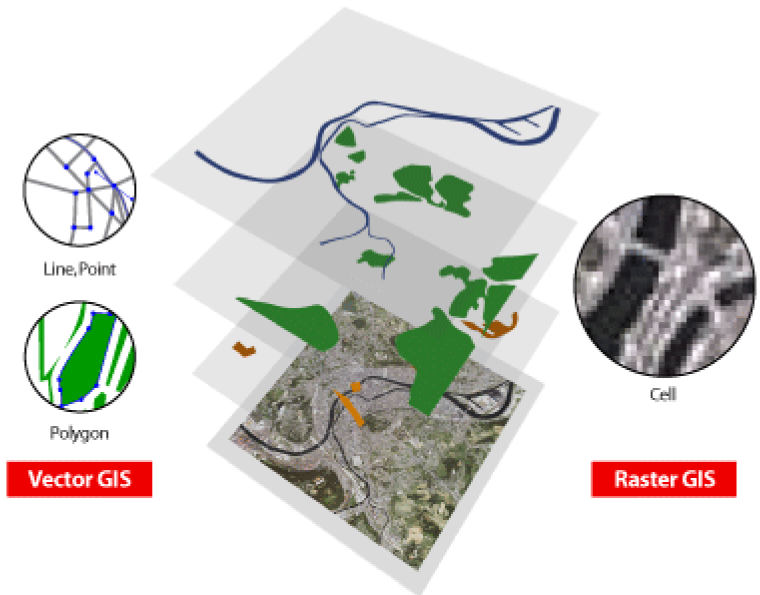
Figure 4: Portrayal Process



The vector to raster transformation is not the only possibility. The portrayal may also present the information as a set of reports, a collection of statistics, or any knowledge that can be extracted from the available geographic information.

The final step is to present to the user an integrated view of multiple sources, giving him the ability to take the right decision. This operation consists of overlaying a set of information layers as native rasters with portrayed vector information. This simple operation may become very difficult with the variety of format and spatial reference systems. Fortunately, this is where you receive the true benefit of the interoperability of the ERDAS APOLLO system.

Figure 5: Raster and Vector Layers



Spatial Reference Systems (SRS)

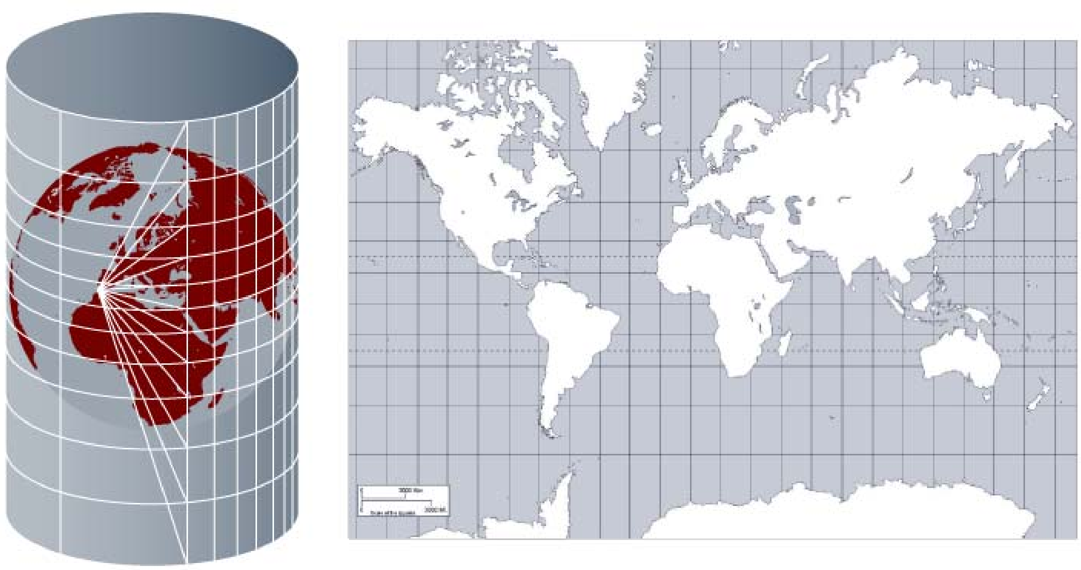
In the process of mapmaking, map projections are needed to portray the real surface of the Earth on a flat surface. The surface of the Earth is first approximated by a geoid. The geoid is a surface that is defined as the locus of all points with equal gravity at mean sea level. Due to the irregular mass distribution in the Earth's interior, the geoid has an irregular shape which makes it unsuitable to use in calculations on spatial data. That is why the geoid is approximated by the nearest regular body, a spheroid, which is often also referred to as an ellipsoid. The ellipsoid is much easier to work with mathematically than the geoid. It forms the basis of the best-known type of coordinate reference systems: the Geographic SRS. The position of a point relative to the ellipsoid is then expressed by means of geographic coordinates: geodetic latitude and geodetic longitude.

Unfortunately, there is not just one ellipsoid that represents the Earth. The size and shape of the ellipsoid are traditionally chosen so that the surface of the geoid is matched as closely as possible to the Earth region from which the data was taken. That choice results in the definition of the origin, orientation, size and shape of the ellipsoid. This concept is called "geodetic datum".

A Geographic SRS is still not suitable for mapmaking, because it describes geometry on a curved surface. It is impossible to represent such geometry in a Euclidean plane without introducing distortions. The control of those distortions is part of the science of map projections. A map projection is a set of formulae that converts the geodetic latitude and longitude to plane map coordinates. The Spatial Reference System, as defined by OGC, is a text parameter that names a horizontal coordinate reference system code.

The OGC Web Map Specification mentions two namespaces: EPSG and AUTO. The EPSG namespace makes use of the European Petroleum Survey Group tables [EPSG], which define numeric identifiers for many common map projections and which associate projection or coordinate metadata (such as measurement units or central meridian) for each identifier. The AUTO namespace is used for "automatic" projections; that is, for a class of projections that include an arbitrary center of projection.[3]

Figure 6: Mercator Projection



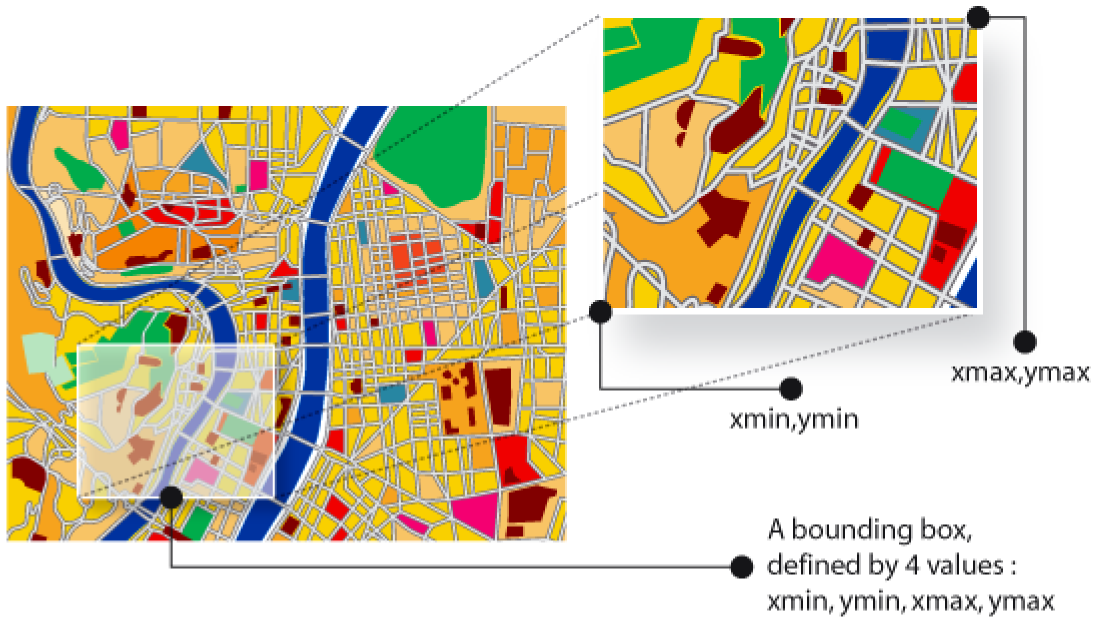
The above figure illustrates distortion of the SRS. On a curved surface, the dimensions of the placement of each country are accurately proportional. However, to display this information on a flat surface, one of four elements must be distorted - area, shape, size or direction. The projection displayed above is an example of an azimuthal projection which preserves area and shape but distorts direction and size.

Bounding Box

The bounding box specifies the extent of the geographic area that you wish to display by using coordinate values of the chosen SRS.

According to the OGC WMS specifications, the bounding box (BBOX) is a set of four comma-separated decimal, scientific notation, or integer values (if integers are provided where floating point is needed, the decimal point is assumed at the end of the number). These values specify the minimum X, minimum Y, maximum X, and maximum Y ranges (in that order), expressed in units of the SRS of the request, such that a rectangular area is defined in those units. A Bounding Box should not have a zero area.[4]

Figure 7: Example of a Bounding Box



Metadata

Metadata is basically textual data that describes data. It often includes elements such as data creation date, lineage (history) of the data, data type, and common usages of the data.

According to ISO, the need for metadata has been created due to... "a revival in the awareness of the importance of geography and how things relate spatially, combined with the advancement of electronic technology that has caused an expansion in the use of digital geographic information and geographic information systems worldwide. Increasingly, individuals from a wide range of disciplines outside of the geographic sciences and information technologies are capable of producing, enhancing, and modifying digital geographic information. As complexity and diversity of geographic datasets grow, a method for providing an understanding of all aspects of this data grows in importance."

"Digital geographic data is an attempt to model and describe the real world for use in computer analysis and graphic display of information. Any description of reality is always an abstraction, always partial, and always just one of many possible 'views'. This 'view', or model of the real world is not an exact duplication; data is often approximated, others are simplified, and other things are ignored. There is seldom perfect, complete, and correct data. To ensure that data is not misused, the assumption and limitation affecting the creation of data must be fully documented. Metadata allows a producer to describe a dataset fully so that users can understand the assumptions and limitations and evaluate the dataset's applicability for their intended use."

"Typically, geographic data is used by many other people other than the provider. It is often produced by one individual or organization and used by another. Proper documentation will provide those unfamiliar with the data with a better understanding, and enable them to use it properly. As geographic data producers and users handle more and more data, proper documentation will provide them with a keener knowledge of their holdings and will allow them to better manage data production, storage, updating, search and discovery as well as reuse."

The ISO 19115 Metadata standard provides a structure for describing digital geographic data. It defines metadata elements, provides a schema and establishes a common set of metadata terminology, definitions and extension procedures.

Effects of Implementing Metadata

When implemented by a data provider, metadata:

- Provides data providers with appropriate information to characterize their geographic data properly
- Facilitates the organization and management of metadata for geographic data

- Enables users to apply geographic data in the most efficient way by knowing its basic characteristics

- Facilitates data discovery, retrieval and re-use. Users will be better able to locate, access, evaluate, purchase, and utilize geographic data

- Enables users to determine whether geographic data will be of use to them

Footnotes

[1] www.opengeospatial.org

[2] Actually, an image is a raster which model can be mapped to a human friendly representation without any complex operation.

[3] www.opengeospatial.org (The OGC Abstract Specification - Topic 2: Spatial Referencing by Coordinates and the OGC Web Map Service Implementation Specification)

[4] www.opengeospatial.org (WMS specifications 1.0)

Standards

In this chapter:

- **What Are Standards?**
- **Why Use Standards for Geospatial Information?**
- **Who Created the Standards Used by ERDAS APOLLO?**

What Are Standards?

Standards are documented agreements that contain technical specifications or other precise criteria to be used consistently as rules, guidelines, or definitions of characteristics, to ensure that materials, products, processes and services are fit for their purpose. The existence of non-harmonized standards for similar technologies in different countries or regions can contribute to technical barriers to trade. Export-minded industries have long sensed the need to agree on world standards to help streamline the international trading process. International Standards thus contribute to making life simpler, and to increasing the reliability and effectiveness of the goods and services we use.[6]

Why Use Standards for Geospatial Information?

Historically, geographic information has been handled in a variety of different data structures and architectures. Due to the nature of GIS, data sharing is extremely important in order to create a complete and correct solution to a geographic-based problem. Though authors of many proprietary off-the-shelf software systems have created conversion programs to convert from one software file type to another, this often compromises geographic data quality, thereby making the data incorrect, unusable or inaccessible.

Standards address the problem stemming from geographic data incompatibilities and proprietary file format transformation problems to create an open world of exchange.

Open interface specifications enable content providers, application developers and integrators to focus on delivering more capable products and services to consumers in less time, at less cost, and with more flexibility.

“The focus of geo-spatial standards is to define the basic semantics and structure of GI for data management and data interchange purposes, and to define GI service components and their behavior for data processing purposes.[7]

Who Created the Standards Used by ERDAS APOLLO?

There are several organizations that seek to create and enforce standards in geographic information. ERDAS APOLLO is based on ISO and OGC standards, as these organizations are world-wide and have been accepted as global standards by a variety of governing bodies and businesses. Both of these organizations rely on a committee of top experts in the GI industry and use an iterative process to enhance the manner in which geographic information is utilized across several vertical markets.

Open Geospatial Consortium (OGC)

The OGC is an international industry consortium of more than 230 companies, government agencies, and universities participating in a consensus process to develop publicly available geoprocessing specifications. Open interfaces and protocols defined by OGC specifications support interoperable solutions that geo-enable the Web, wireless and location-based services, and mainstream IT, and empower software developers to make complex spatial information and services compatible with all kinds of applications.

OGC members are evenly distributed across the world, with members from different continents. All standards are decided upon by using a process of collaborative decision-making. Agreement from all members is required before a standard is passed and all standards are based on real-life situations. The OGC standards define only the interface of the implementation - not the implementation itself.

International Standards Organization (ISO)

The International Organization for Standardization (ISO) is a worldwide federation of national standards bodies from more than 140 countries, one from each country. ISO is a private sector organization established in 1947. The mission of ISO is to promote the development of standardization and related activities in the world with a view to facilitating the international exchange of goods and services, and to developing cooperation in the spheres of intellectual, scientific, technological, and economic activity. ISO's work results in international agreements which are published as International Standards.

The ISO 211 working group is the ISO group responsible for the standards that deal with Geographic Information and Geomatics . This working group states that its mission is "to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth."

World Wide Web Consortium (W3C)

The World Wide Web Consortium (W3C) both develops and promotes standard technologies for the Web. On the W3C Web site, you will find information about Web technologies such as the Hypertext Markup Language (HTML), the Extensible Markup Language (XML), Cascading Style Sheets (CSS), or Scalable Vector Graphics (SVG) . W3C is an international consortium with over 500 Members and a full-time staff of more than 60 people. W3C is led by Tim Berners-Lee, who is credited with inventing the World Wide Web.[8]

Footnotes

[6] www.opengeospatial.org, www.iso.org

[7] www.iso.org (ISO specification - 19101)

[8] www.w3c.org

GI Standards in Detail

In this chapter:

Standards in GI

Standards in GI range from standard data formats (as seen above), standards for web storage and publishing and standards/encodings for data transport.

Web Services Standards

Web Coverage Service (WCS)

The Web Coverage Service (WCS) supports the electronic interchange of geospatial data as "coverages", which is defined as digital geospatial information representing space-varying phenomena.

The Web Coverage Service provides access to intact (unrendered) geospatial information (such as temperature, cloud cover) as needed for client-side rendering, and input into scientific models.

Coverage Portrayal Services

The Coverage Portrayal Service (CPS) is a mechanism that renders graphical pictures from coverage data. Typically, coverage data are retrieved from a Web Coverage Service (WCS). The CPS facilitates wider use of coverage data by making graphical representations of coverages that can be shown in client web browsers. The CPS works as an intermediary between the client application and the WCS. Once the client has built a GetMap request and a Styled Layer Descriptor (SLD) document, it sends them to the CPS. The CPS will analyze the request and the SLD, and send a GetCoverage request to the underlying WCS. The WCS will return a coverage that the CPS will render by applying portrayal directives (image size, format, reprojection, classification, etc.) found in the request and in the SLD document.

Web Map Service (WMS)

A Web Map Service (WMS) is a web interface that allows you to publish and deploy geographic maps on the internet.

The WMS is an official specification from the OGC which defines a WMS as "a set of interface specifications that provide uniform access by web clients to maps rendered by map servers on the **Internet**. A Web Map Service produces maps of geo-referenced data. The WMS specification standardizes the way clients request a map and the way servers describe their data holdings." [9]

Thus, WMS is a service interface specification that:

- Enables the dynamic construction of a map as a picture, as a series of graphical elements, or as a packaged set of geographic feature data
- Answers basic queries about the content of the map
- Can inform other programs about the maps it can produce and provides metadata about the served data

The WMS is deployed in such a way that you can query the server and obtain certain information about the data or the capabilities of the data services. The following WMS operations are valid requests to the WMS from a client-side application.

WMS Operations

- **GetCapabilities** - Obtains the capabilities of the server using service-level metadata. This is a description of the WMS information content.

- **GetMap** - Obtains the map (raster data or image file) whose geo-spatial and dimensional parameters should be defined by the data service provider's WMS.

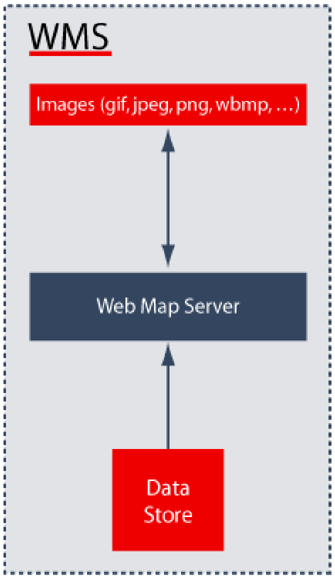
- **GetFeatureInfo** - Obtains information about particular features shown on the image or raster file.

When invoking GetMap, a client can specify the following:

- the information to be shown on the map (one or more layers) and possibly the styles of those layers
- the portion of the Earth to be mapped (the bounding box)
- the geographic or projected coordinate system to be used (the Spatial Reference System, or SRS)
- the desired output format
- the output size (width and height)
- background transparency
- color

When more maps are produced with the same bounding box, SRS, and output size, the results can be accurately layered by the client to produce a composite map. The use of image formats that support transparent backgrounds, such as SVG, GIF, or PNG, allows the lower map layers to be visible. Furthermore, individual map layers can be requested from different servers.

Figure 8: WMS Architecture



The above figure illustrates the WMS architecture. Your data is stored and made accessible to others for use by means of the WMS.

ERDAS APOLLO software also provides additional WMS functionality to you above and beyond the OGC specifications. Sophisticated Web Map Servers can enhance the basic OGC WMS specification via the use of proxy WMS capabilities. A proxy WMS enables a “cascading” process, whereby the proxy WMS acts as a client of other WMSs, and, in turn, performs WMS services to other clients. The OGC WMS specification notes: “This provides a convenient mechanism for aggregating the capabilities of the individual Map Servers into one logical ‘place.’ Additionally, a proxy WMS can perform additional services. Consider a proxy WMS that can convert many different graphics formats, such as GIF, PNG, JPEG, etc. into GIF format. Then, client viewers that can only display GIF could still benefit from the output of map servers that produce only JPEG or PNG. Similarly, a Proxy WMS might perform coordinate transformations on behalf of other servers.[10]

Web Feature Service (WFS)

A Web Feature Service (WFS) is a web interface that allows you to publish and deploy geographic feature data on the internet.

WFS is an official specification from the OGC which "provides an interface for describing data manipulation operations (create, delete, update, and get features) on geographic data stored in databases that are accessible over internet infrastructure, such as World Wide Web, WANs, LANs, etc. The WFS interface exposes the data in these repositories as Geography Mark-up Language (*GML*)." [11]

A WFS based on OGC specifications can be implemented in either its **Basic** version, or a **Transactional** version. Basic WFSs are READ-ONLY Web Feature Servers while a transactional Web Feature Server (WFS-T) can support all the interfaces of a basic WFS and also implement a type of file locking (LockFeature) and transactional interfaces. This allows multiple users to do a variety of manual operations, such as create/update/delete data or make informatory requests simultaneously on the same geographic feature.

WFS Operations

- **GetCapabilities** -You can send a request to a WFS asking what capabilities the server holds. Specifically, the WFS should indicate which feature types it can service, what operations are supported on each feature type, and what metadata is associated with each data source.

- **DescribeFeatureType** - The server should be able, upon request, to describe in an XML schema the structure of any feature type it can service .

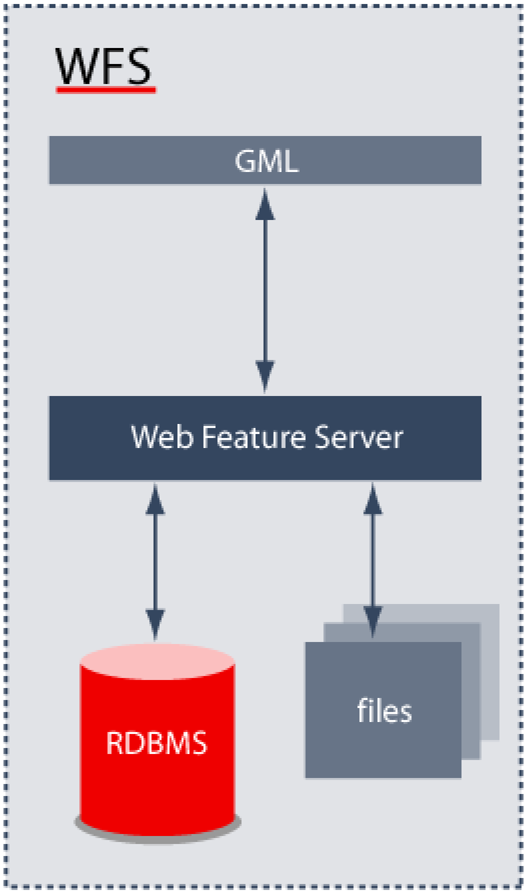
- **GetFeature** - The server should be able to service a request to retrieve feature instances. In addition, the client should be able to specify which feature properties to fetch and constrain the query spatially and non-spatially.

- **LockFeature** - A transactional WFS may be able to process a lock request on one or more instances of a feature type for the duration of a transaction. This ensures that transactions in series are supported.

- **Spatial Operators and Filters** - There are several different spatial filters and operators that can be issued to the WFS.

- **Transaction** - A transactional WFS may be able to service transaction requests. A transaction request is composed of operations that modify features; that is create, update, and delete operations on geographic features.

Figure 9: WFS Architecture



The above figure illustrates the WFS architecture. Your feature data are stored and made accessible to others for use by means of the WFS. You are able to choose which users can access your data, and place permissions or restrictions on certain data sets, ensuring the security of your data via the server.

Web Annotation Service

Imagery analysts and other users of imagery and maps often need to summarize the essential content of an image, point out features of interest, or express similarities or differences between images. Likewise, GIS specialists often need to highlight spatial patterns, label certain features, or otherwise "mark up" a map. These maps and images can communicate valuable information.

Encoding annotations in an interoperable way will make it easier and more flexible for users to:

- Exchange annotated maps and images.
- Integrate image interpretation with raw imagery.

Annotations are features describing a given place that can be shared among different users of the system. An annotation feature consists of a geometry, a name, and a description.

The annotation service wraps WFS that is configured to store annotations as features. The ERDAS APOLLO implementation of the annotation server is an authenticated service, so users must provide both an ID and a password. Each authenticated user may create annotations and share or protect them from other users.

Web Gazetteer Service (WFS-G)

A gazetteer is a geographical dictionary, which is essentially a list of geographic (place or feature) names, with references to their location and containing associations to descriptive information.

A gazetteer service is a network-accessible service that retrieves one or more features from a gazetteer, given a query (filter) request. It exposes both a potentially structured vocabulary and a feature collection, and also may support the capabilities of a hierarchical vocabulary and a Web Feature Server (WFS).

A Web Gazetteer Service is a specialized Web Feature Service that provides additional capabilities specific to a gazetteer-like feature collection.

Additionally, the Web Gazetteer Service exposes the following interfaces (using HTTP) to query, insert, and update location instances in a gazetteer database:

- **Get or Query Features** – This request retrieves features based on thesaurus-specific properties;
- **GetCapabilities** - This request retrieves properties of the gazetteer database, such as the location type class and/or the spatial reference system.

Catalogue Service for the Web (CSW)

Catalogue Service for the Web (CSW) is a web interface that supports the storage, retrieval, and management of data related to web services. It is a key component in a service-oriented architecture that manages shared resources and facilitates the discovery of resources within an open, distributed system. ERDAS's answer to this interface is the CSW endpoint of the ERDAS APOLLO Catalog component, which offers a CSW-compliant view on the content of the ERDAS APOLLO Catalog.

The preferred OGC registry information model is based on the ebXML registry information model. This is called the ebRIM Application Profile for CSW.

CSW supports registration, metadata harvesting and descriptor ingestion, push and pull update of descriptors, and discovery of OGC Web Service types and instances.

Facilities are provided for the URL entry of OGC Web Service capabilities into the system for ingestion as well as the automatic harvesting of this data into the system at previously specified intervals so that it is available for service discovery via "viewer" clients. Service providers may also view, modify, and delete their entries from the system, although modification and deletion operations require preconfigured privileges. In addition, service discovery is facilitated through a well-defined search interface.

The Catalog as a Type Management System

- Provides persistent information for use in service discovery
- Facilitates dynamic binding to services instances
- Guarantees classification of the registered services

Encoding Standards

Filter Types and Encodings

Filter expressions are encodings used to identify a subset of object instances to be operated upon by constraining property values of an object type. Filters for geographic information are widely available and follow a variety of different formats. In ERDAS APOLLO Server, we rely upon the OGC Filter Encoding Specification 1.0 to define which filter types are valid in our product components, such as the WFS, CSW, and SLD. OGC filters are written in XML and are the equivalent of a SQL *WHERE* clause that allows restriction of features extracted from the data set by expressing operations on scalar or geometric properties.

Because all filter expressions for OGC are based on XML, the filters must be able to address feature names and properties encoded as XML elements or attributes. Therefore, all filter expressions follow a subset of XPath, the WC3 XML Path Language. This is a specification for addressing parts of an XML document or referencing feature properties that are encoded as XML elements or attributes. The filter specification only needs a subset of the XPath language to define an OGC compliant filter expression; it does not need to support the full XPath language. For more information on filters, consult the OGC Filter Encoding Specification 1.0. For more information about XPath, please refer to the **W3C specification**.

Spatial filters are often referred to as map algebra. These spatial filters are a subset of the available topological operators that allow one to do analysis and problem solving on spatial or geographically-based data.

Scalar filters compare or restrain the magnitude of various data aspects. These filters include the ability to process logical expressions, comparisons, and/or arithmetical operations.

Spatial Filters

The following are spatial filter operators based on the ISO and OGC geometry models:

- **Disjoint** - a geometric relationship where two objects do not interact in any way. Two disjoint objects do not share any elements or pieces of their geometry.

- **Touches** - a geometric relationship where two objects share a common point on their boundaries, but their interiors do not intersect.

- **Crosses** - two lines cross each other if they meet on an internal point. Note that this relationship is different than a touch relationship because a touch is only on the boundaries. Similarly, a line crosses an area if the line is partly inside the area and partly outside.

- **Within** - when a geometry 's interior and boundary are completely contained by another geometry, it is said to be ***within*** the second geometry.

- **Overlaps** - the interior of one geometry is partially included in the interior of another geometry and vice versa.

- **Equals** - a geometric relationship in which two objects are considered to represent the same geometric figure. The two objects must be composed of the same number of points, although the ordering of the points defining the two objects' geometries may differ (clockwise or counterclockwise).

- **Intersect** - the topological integration of two spatial data sets that preserves features that fall within the area common to both input data sets.

- **Contains** - describes a geometric relationship where one object encompasses another and the interior object does not touch any boundaries of the exterior object. The outer object contains the inner object.

- **Beyond** - the operator tests whether the value of a geometric property is beyond a specified distance of the specified literal geometric value.

- **Within** - this operator is the opposite of beyond and similar to a buffer operation.

Scalar Filters/Common Catalog Query Language

The definition of scalar relates to a quantity of something that has magnitude, but no direction. OGC defines the following types of operators as scalar:

- **Logical** expressions are used to process **AND**, **OR**, or **NOT** operators.

- **Comparison** operations are used to indicate the types of comparison operators supported by a service. Simple comparisons such as **=**, **<**, **<=**, **>**, and **>=** are supported. Elements such as **LIKE**, **BETWEEN**, and **NULLCHECK** are used to indicate whether the service can support a like, between or null operator.

- **Arithmetic** operators elements can be used to determine which arithmetic operators the services support. Simple arithmetic is used to indicate that the service supports addition, subtraction, multiplication, and division. The functions elements indicates whether additional functions are available via the service.

Logical

The operators **AND**, **OR**, and **NOT**, are logical, boolean operators.

AND: This logical operator is used in queries to specify that both condition 1 AND condition 2 must be met before data is returned. When used in combination with a logical OR operator, the AND operator takes precedence over the OR operator. For example, the expression "condition 1 AND condition 2 OR condition 3" is evaluated as (condition 1 AND condition 2) OR condition 3. Typically, parentheses are used in queries that have both AND and OR operators to ensure the correct order of precedence.

OR: This operator is used to specify that you would data returned from either or both condition 1 or condition 2 is met. See the above explanation for more information about using the OR operator with the AND operator. If order is not explicitly and properly defined in the WHERE clause, the OR operator can produce every possible combination.

NOT: This operator returns TRUE if its operand is FALSE, and FALSE if its operand is TRUE. NOT is used to perform logical negation on a single condition.

Comparison

PropertyIsEqualTo - The equality operator defines the relationship that two numeric or text properties are equal if both their values are equal.

PropertyIsLessThan - The less than operator defines the relationship that a numeric or text property is less than another if its magnitude is less than the other one.

PropertyIsGreaterThan - The greater than operator defines the relationship that a numeric or text property is greater than another if its magnitude is greater than the other one.

PropertyIsLessThanOrEqualTo - The less than or equal to operator defines the relationship that a numeric or text property is less than another if its magnitude is less than the other one or that the two numeric or text properties are equal if both their real parts and imaginary parts are equal.

PropertyIsGreaterThanOrEqualTo - The greater than or equal to operator defines the relationship that a numeric or text property is greater than another if its magnitude is greater than the other one or that the two numeric or text properties are equal if both their real parts and imaginary parts are equal.

PropertyIsLike - The PropertyIsLike operator retrieves records where a text string appears and reflects the placement of the specified value(s). It finds patterns in character string data. Comparisons can be made only between compatible data types. PropertyIsLike allows the use of a wildcard, which is a character that may be substituted for any of a defined subset of all possible characters. The two most common wildcards used with the PropertyIsLike operator are the percent (%) and underscore (_) characters.

PropertyIsNull - Retrieves only records where the item HAS NO value.

PropertyIsBetween - Retrieves only records where the item lies BETWEEN (and EQUALS) the specified values.

Arithmetic

ADD - Addition is an arithmetic operator used to add two numbers.

SUB - Subtraction is an operator used to subtract two numbers or to change the sign of a number.

MUL - Multiplication is an arithmetic operator used to multiply two numbers.

DIV - Division is an arithmetic operator used to divide two numbers and return a floating-point result.

Arithmetic operators can also include functions, which are specific types of procedures that perform a distinct computation. A function may accept zero or more arguments as input and generate a single result. A function is composed of the name of the function encoded using the attribute name and zero or more arguments contained within the <functions> element. The arguments themselves are expressions.

The ERDAS APOLLO Server WFS supports the following Oracle-based expressions: **Upper** and **Lower** to reference the character datatype for string based expressions, **Distance** to determine if two geometries are within a specified distance from one another, and **Score** to allow the ordering of a query result.

More Information

In the context of a WFS, the capabilities request will publish the specific operators supported. A WFS may support one of any of the OGC operators available. The decision of which filters to support and when to support them is really up to the implementors and publishers of the WFS.

The following is an example of a capabilities fragment for a service that supports some of the filtering capabilities defined in this document. This example also demonstrates named arithmetic functions.

Example: Operators in Capabilities

```
<Filter_Capabilities>
   <Spatial_Capabilities>
      <Spatial_Operators>
         <BBOX/>
         <Equals/>
         <Disjoint/>
         <Intersect/>
         <Touches/>
         <Crosses/>
         <Within/>
         <Contains/>
         <Overlaps/>
         <Beyond/>
      </Spatial_Operators>
   </Spatial_Capabilities>
   <Scalar_Capabilities>
      <Logical_Operators/>
      <Comparison_Operators>
         <Simple_Comparisons/>
         <Like/>
         <Between/>
         <NullCheck/>
      </Comparison_Operators>
      <Arithmetic_Operators>
         <Simple_Arithmetic/>
         <Functions>
              <Function_Names>
                  <FunctionNamenArgs="1">MIN</FunctionName>
                  <FunctionNamenArgs="1">MAX</FunctionName>
                  <FunctionNamenArgs="1">SIN</FunctionName>
                  <FunctionNamenArgs="1">COS</FunctionName>
                  <!--.
                      .…more functions defined here…
                      .
                  -->
              </Function_Names>
           </Functions>
      </Arithmetic_Operators>
</Scalar_Capabilities>
</Filter_Capabilities>
```


If you would like more information, please refer to the following links: http://www.opengeospatial.org for the OGC Simple Feature-SQL and Filter Encoding Specifications, http://www.oracle.com for more information about Oracle spatial operators, and http://www.java.com for Java JTS filter specifications.

Geography Markup Language (GML)

GML is an open, non-proprietary language used to created geospatial objects for the purpose of data sharing. GML also serves as a data transport for geospatial objects and provides a means for describing geospatial web services.

About GML

- Provides an open, vendor-neutral framework for the definition of geospatial application schemas and objects
- Allows profiles that support proper subsets of GML framework descriptive capabilities
- Supports the description of geospatial application schemas for specialized domains and information communities
- Enables the creation and maintenance of linked geographic application schemas and datasets
- Supports the storage and transport of application schemas and data sets
- Increases the ability of organizations to share geographic application schemas and the information they describe

The previous version (2.1.2) of GML was concerned with what the OGC calls *simple features*, or features whose geometric properties are restricted to 'simple' geometries for which coordinates are defined in two dimensions and the delineation of a curve is subject to linear interpolation.

GML3, or the current version (3.1.1) of GML, handles the following needs that were not addressed or adequately met by the previous version:

- Represents geospatial phenomena in addition to simple 2D linear features, including features with complex, non-linear, 3D geometry, features with 2D *topology*, features with temporal properties, dynamic features, coverages, and observations
- Provides more explicit support for properties of features and other objects whose value is complex
- Represents spatial and temporal reference systems, units of measure, and standards information
- Uses reference system, units, and standards information in the representation of geospatial phenomena, observations, and values
- Represents default styles for feature and coverage visualization

GML version 3.1.1 maintains backward compatibility for GML version 2.1.2 instance documents by preserving, but deprecating, some schema components that have been replaced by different constructs in the current version. [12]

Scalable Vector Graphics (SVG)

SVG stands for Scalable Vector Graphics and is an XML grammar for stylized graphics.

Scalability infers that something can increase or decrease uniformly. SVG graphics are scalable to different display resolutions for different uses. A printed SVG graphic will use the full resolution of the printer and also display at the same size on screens of different resolutions. The same SVG graphic can be placed at different sizes on the same Web page and re-used at different sizes on different pages. SVG graphics can be magnified to see fine detail. SVG graphics can also be referenced or included inside other SVG graphics to allow a complex illustration to be built up in parts, perhaps by several people.

SVG models graphics at the graphical object level rather than as individual points. SVG includes font elements so that both the text and graphical appearance are preserved.

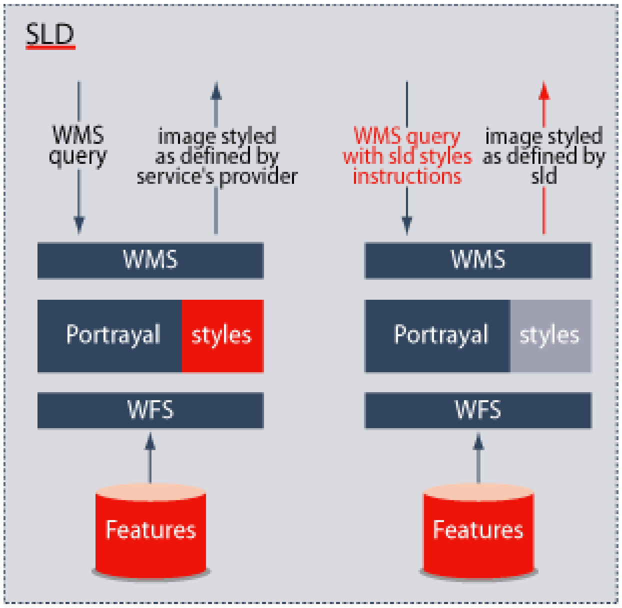
Vector graphics contain geometric objects, such as lines and curves. Typically, vector graphics can also integrate raster images and can combine them with vector information such as clipping paths to produce a complete illustration, and SVG is no exception.

SVG fills a gap in the market of XML grammars by providing a rich, structured description of vector and mixed vector/raster graphics. It can be used in a stand-alone fashion, or as an XML namespace with other grammars. Since it is written in XML, SVG builds on this strong foundation and gains many advantages such as a sound basis for internationalization, powerful structuring capability, and an object model. SVG graphics may also be included in a document which uses any text-oriented namespace, including XHTML. [13]

Styled Layer Descriptor (SLD)

SLD defines a styling language that the client and server can both understand, to portray the output of Web Map Servers, Web Feature Servers, and Web Coverage Servers.

Figure 10: SLD - Architecture



The above figure illustrates the SLD architecture in the ERDAS APOLLO Server product. While the complete SLD mechanism is intended for adding to WMS requests, the portrayal engine contained in this product is also able to style specific feature types using a subset of the SLD tags.

OGC Web Map Contexts

A context is an XML document that essentially stores WMS service URLs, layers you want to view on each server, and the area of interest for each layer. A mapping client can then just read the context file and display a map that you can modify or send without having to host the data or be tied to a specific server. Context documents include information about the servers providing the layer in the overall map, the bounding box and map projection shared by all the maps, sufficient operational metadata for client software to reproduce the map, and ancillary metadata used to annotate or describe the maps.

Why use a Context?

The context document makes a map that is assembled from several different services easier to view and style. The context document can provide a convenient default startup view for users who often deal with only one designated set of geospatial information.

Ease of Use

Human readers can easily understand the context document because it is written in XML. The context document stores not only the current settings, but also additional information about each layer such as available styles, formats, and SRS. This makes map viewing and manipulation easier for the end user because it is not necessary to re-query map servers for layers that are contained within the context each time they are accessed.

Flexibility

The context document can be saved from one client session and transferred to a different client application to start up with the same context. Contexts could be cataloged and discovered, thus providing a level of granularity broader than individual layers.

Example: Beginning of a Context document

```
<![CDATA[<?xml version="1.0" encoding="utf-8"?>
<xs:schema version="1.0.0"
    xmlns:xs="http://www.w3.org/2001/XMLSchema"
    targetNamespace="http://www.opengis.net/context"
    xmlns:context="http://www.opengis.net/context"
    xmlns:sld="http://www.opengis.net/sld"
    xmlns:xlink="http://www.w3.org/1999/xlink"
    elementFormDefault="qualified">
  <xs:import namespace="http://www.opengis.net/sld"
      schemaLocation="http://schemas.opengis.net/sld/1.0.0/sld.xsd"/>
  <xs:element name="ViewContext" type="context:ViewContextType"/>
  <xs:complexType name="ViewContextType">
    <xs:sequence>
      <xs:element name="General" type="context:GeneralType"
          minOccurs="1" maxOccurs="1"/>
      <xs:element name="LayerList" type="context:LayerListType"
          minOccurs="1" maxOccurs="1"/>
    </xs:sequence>
    <xs:attribute name="version" type="xs:string" use="required" fixed="1.0.0"/>
    <xs:attribute name="id" type="xs:string" use="required"/>
  </xs:complexType>
  <xs:complexType name="GeneralType">
    <xs:sequence>
      <xs:element name="Window" type="context:WindowType"
          minOccurs="0" maxOccurs="1"/>
      <xs:element name="BoundingBox" type="context:BoundingBoxType"
          minOccurs="1" maxOccurs="1"/>
      <xs:element name="Title" type="xs:string"
          minOccurs="1" maxOccurs="1"/>
      <xs:element name="KeywordList" type="context:KeywordListType"
          minOccurs="0" maxOccurs="1"/>
      <xs:element name="Abstract" type="xs:string"
          minOccurs="0" maxOccurs="1"/>
      <xs:element name="LogoURL" type="context:URLType"
          minOccurs="0" maxOccurs="1"/>
      <xs:element name="DescriptionURL" type="context:URLType"
          minOccurs="0" maxOccurs="1"/>
      <xs:element name="ContactInformation" type="context:ContactInformationType"
          minOccurs="0" maxOccurs="1"/>
      <xs:element name="Extension" type="context:ExtensionType"
          minOccurs="0" maxOccurs="1"/>
    </xs:sequence>
  </xs:complexType>
</xs:schema>]]>
```

More Information

If you would like more information, please see http://www.opengeospatial.org for the OGC Web Map Context Document Specification.

Footnotes

[9] www.opengeospatial.org

[10] OGC® Web Map Server Interface Implementation Specification Revision 1.0.0, OGC Project Document 00-028, Open Geospatial Consortium, 2000

[11] www.opengeospatial.org

[12] OGC GML 3.1.1 specification

[13] Information provided from the W3 spec for SVG. The structure has been modified slightly in order to present the information succinctly.

Glossary

The glossary terms defined in this guide are those used in all ERDAS APOLLO guides.

A

Ant

Apache Ant is a Java-based build tool from the **Jakarta Project**.

Applet

A component that typically executes in a web browser, but can also be executed in a variety of other applications or devices that support the applet application model.

Area

Area is defined by a two dimensional (area) feature represented by a line that closes on itself to form a boundary.

B

Bounding Box

A bounding box is defined as the extent of the geographic area that you wish to display by using coordinate values of the chosen Spatial Reference System.

C

Connector

A class of connection to a specific type of data source.

Coordinate

One of a sequence of N numbers designating the position of a point in N-dimensional space. In a coordinate reference system, the coordinate numbers must be qualified by units.

Coordinate System

Set of rules for specifying how coordinates are to be assigned to points. One coordinate system may be used in many coordinate reference systems.

Coordinate Transformation

Computational process of converting a position given in one coordinate reference system into the corresponding position in another coordinate reference system.

D

Dimension

A OGC-WMS 1.1.1 mechanism that allows the application of a Filter in a GetMap request.

E

Elevation

In the context of the OGC-WMS 1.1.1 interfaces, Elevation is a parameter that can be given in a GetMap request. It represents a given type of Dimension, a concept also explained in that specification.

Ellipsoidal

An ellipsoidal surface is a geometric surface, all of whose plane sections are either ellipses or circles.

EPSG

EPSG is defined as a type of geographic projection. The EPSG namespace makes use of the European Petroleum Survey Group tables, which define numeric identifiers (the EPSG "SRS code," corresponding to the field "COORD_REF_SYS_CODE" in the EPSG database) for many common projections and which associate projection or coordinate metadata (such as measurement units or central meridian) for each identifier.

F

Feature (geographic)

Features are "abstractions of a real world phenomenon; it is a geographic feature if it is associated with a location relative to the Earth.”

Feature Types

The number and kind of properties a feature has describes its feature type.

Feature Mapping

The mapping is the configuration that describes the link between the FeatureType definition and the objects returned by the underlying engine. The mapping document associated with a WFS service presents the necessary information for the WFS to convert client requests to queries understood by the data server. It also converts the result into a compliant collection of features. So, it makes the link between the internal data structure and the published information.

Feature Schema

The XML Schema associated with a WFS service gives the GML Schema (structure) needed by the WFS to expose its feature types. The schema is the type descriptions structure for each feature type and for each property of those feature types.

G

Get

A GET request is an HTTP request for exchanging information with a server.

Geographic Information

Geographic Information is data that is referenced to locations on the earth's surface, such as digital maps and sample locations.

Geographic Information System

A Geographic Information System is an organized collection of computer hardware, software, geographic data, and personal information designed to efficiently capture, store, update, manipulate, analyze & display all forms of geographically referenced info.

GML

GML is an open, non-proprietary language used to created geo-spatial objects for the purpose of data sharing. GML also serves as a data transport for geo-spatial objects as well as exists as a means for describing geo-spatial Web services.

I

ISO

The International Organization for Standardization (ISO) is a worldwide federation of national standards bodies from more than 140 countries, one from each country. ISO is a non-governmental organization established in 1947. The mission of ISO is to promote the development of standardization and related activities in the world with a view to facilitating the international exchange of goods and services, and to developing cooperation in the spheres of intellectual, scientific, technological and economic activity. ISO's work results in international agreements which are published as International Standards.

Interoperability

Interoperability is the ability of systems, units, or forces to provide services to and accept services from other systems, units or forces and to use the services so exchanged to enable them to operate effectively together. For example, interoperability describes the condition achieved among communications-electronics systems or items of communications-electronics equipment when information or services can be exchanged directly and satisfactorily between them and/or their users. The degree of interoperability should be defined when referring to specific cases. Interoperability is the ability of a system or a product to work with other systems or products without special effort on the part of the customer. Interoperability becomes a quality of increasing importance for information technology products as the concept that "The network is the computer" becomes a reality.

J

JDBC

Java Database Connection. The Java interfaces to database connectivity.

Java Virtual Machine

A software computer that interprets and executes the byte codes in Java class files like a microprocessor would execute machine code.

L

Layer

A layer is a usable subdivision of a dataset, generally containing objects of certain classes, for example rivers, roads or geology.

M

Metadata

Metadata is often textual descriptive data about GI or other types of data. This information will often include some of the following: What it is about? Where it is to be found? Who can access it? In what format it is available? What is the quality of the data for a specified purpose? What spatial location does it cover and over what time period? When and where the data were collected, and by whom and for what purposes the data have been used?

O

Open Geospatial Consortium (OGC)

OGC is an international industry consortium of more than 230 companies, government agencies and universities participating in a consensus process to develop publicly available geoprocessing specifications.

P

Point

A point is a zero-dimensional abstraction of an object represented by a single X,Y coordinate. A point normally represents a geographic feature too small to be displayed as a line or area; for example, the location of a building location on a small-scale map, or the location of a service cover on a medium scale map.

Post

Post is an HTTP request for exchanging information with a server.

Provider

An instance of a connector, for a given data source.

R

Raster

Raster defines a method for the storage, processing and display of spatial data. Each given area is divided into rows and columns, which form a regular grid structure. Each cell must be rectangular in shape, although not necessarily square. Each cell within this matrix contains an attribute value as well as location coordinates. The spatial location of each cell is implicitly contained within the ordering of the matrix, unlike a vector structure which stores topology explicitly. Areas containing the same attribute value are recognized as such, however, raster structures cannot identify the boundaries of such areas as polygons. Also raster structures may lead to increased storage in certain situations, since they store each cell in the matrix regardless of whether it is a feature or simply 'empty' space.

S

Scalable Vector Graphics(SVG)

SVG is an XML grammar for stylable graphics.

Service Oriented Architecture

A service-oriented architecture is a way of connecting applications across a network via a common communications protocol. In theory, this lets developers treat applications as network services that can be chained together to create a complex business processes more quickly.

Servlet Engine

An environment written by a Web server vendor in accordance with this specification that allows servlets to run with a particular Web server.

Shape File

A shapefile stores non-topological geometry and attribute information for the spatial features in a data set. The geometry for a feature is stored as a shape comprising a set of vector coordinates.

Simple Features

Simple Features are in essence a "Lite" version of the ISO model corresponding to the data model required to support basic GIS systems.

Spatial Reference System (SRS)

A SRS is a reference system provides a scale of measurement for assigning values “to a location, time or other descriptive quantity or quality” according to OGC.

Styled Layer Descriptor (SLD)

SLD is a styling language that the client and the server both understand, used to portray the output of the WMS, WFS and Web Coverage services.

Stack Trace

A list of what methods were called, in what order, to invoke the method in which the exception occurred (called a "stack trace" because it prints out a stack of method names).

Struts (Apache Web Application Framework)

Struts encourages application architectures based on the JSP Model 2 approach, a variation of the classic Model-View-Controller (MVC) design paradigm.

Swing, the Java Foundation Classes

The Java Foundation Classes (JFC) are a set of Java class libraries provided as part of J2SE™ to support building graphics user interfaces (GUI) and graphics functionality for Java technology-based client applications.

U

Usability

Usability is defined by the ease with which a user can learn to operate, prepare inputs for and interpret outputs of a system or component.

V

Vector

Vector defines one method of data type, used to store spatial data. Vector data is comprised of lines or arcs, defined by beginning and end points, which meet at nodes. The locations of these nodes and the topological structure are usually stored explicitly. Features are defined by their boundaries only and curved lines are represented as a series of connecting arcs. Vector storage involves the storage of explicit topology, which raises overheads, however it only stores those points which define a feature and all space outside these features is 'non-existent.'

W

WAR file

Web **Ar**chive file: a type of jar file used by servlets.

Webapp

Webapp or Web Application: Groups of server-side Web resources that make up an interactive online application. The Web resources include Java servlets, JSPs, static documents (such as HTML documents), and applets that can be deployed in a client Web browser. Web applications must run in the context of an Application server or Servlet Engine.

WFS

A WMS is an OGC specification for a Web Feature Server.

WMS

A WMS is an OGC specification for a Web Map Server.

X

XML Schema

A language to express XML types. See **http://www.w3.org/XML/Schema**.