Interoperability and Spatial Data Standards

The International Organization for Standardization defines interoperability as "the capacity to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units" (ISO 1993). In the context of geographic information, the functional units are geographic information (GI) systems or Web services. The communication between these units comprises transfer of spatial data as well as querying and execution of remote services. In this respect, two types of interoperability can be distinguished: *syntactic* interoperability refers to format of the transferred data, that is the compliance with spatial data standards; *semantic* interoperability builds on syntactic interoperability and refers to the accurate preservation and interpretation of the *meaning* of the transferred information [see Semantic Interoperability]. The focus of this entry is on syntactic interoperability and the standards enabling heterogeneous GI systems and services to interoperate. Note that the kind of interoperability discussed here relies on lower-level *technical* interoperability, where established standards guarantee that a CD can be read in every CD drive, computers can communicate through telephone wires, electric devices can be operated on every power outlet, and so forth.

Interoperability is a key requirement for the seamless exchange of spatial data between users and organizations employing different GI systems and Web services. On a broader scale, the standards enabling interoperability are the cornerstones of SDIs [see Spatial Data Infrastructure]. Without agreements on the formats of the transferred spatial data and the interfaces for accessing the corresponding Web services, mutual data exchange between different GI systems would at least require manual transformation of the data or even be impossible

altogether. The most important organizations that develop such standards for the geospatial domain are the OGC [see Open Geospatial Consortium] and the ISO/TC211 (see http://www.isotc211.org/), responsible for geographic information / geomatics. Both organizations have a working agreement, resulting in a frequent mutual adaptation of standards.

Data Interoperability

Before the Web became a common platform for the exchange of geodata, interoperability mainly concerned the exchange of spatial data between different desktop GIS workstations on different kinds of media. Early exchange formats for spatial information such as ESRI's shape file format were de-facto standards stemming from the widespread use of their ArcGIS and ArcView software. In order to enter the market, other software vendors had to support these proprietary formats that are still common today. Besides specialized GIS formats, vector data were often exchanged in file formats originally developed for computer aided design (CAD) software. Raster data were (and still are) mostly exchanged in standard graphics file formats such as JPEG, PNG or (georeferenced) TIFF.

In a more contemporary sense, interoperability is usually reached by standards that are established by industrial consortia or independent standardization organizations. One such vendor-neutral standard for geographic features that is commonly used today is the Geography Markup Language (GML) introduced by the OGC. GML is an eXtensible Markup Language (XML) encoding for the transport and storage of geodata that can be tailored to specific applications via application schemas. Application schemas define the specific feature types and property types that are relevant for a given domain based on the GML meta schema. Due to the complexity of GML caused by this multi-purpose design, numerous developers favored the simpler Keyhole Markup Language (KML), especially for non-professional or Web 2.0 mash-

ups. KML was originally a propriety format used in Google Earth and has been put under control of the OGC in 2007. It became an open OGC standard in 2008.

Besides the actual data, their descriptions in metadata [see Metadata] must also be standardized in order to allow interoperable data discovery in catalogue services. This standardization refers to the metadata encoding as well as the minimum set of mandatory properties, allowing for metadata profiles for different applications. The ISO 19115 specification (part of the ISO 191xx set of standards for geographic information) provides such a standard specifically developed for metadata on geodata. It comprises over 400 different elements, of which a small subset is compulsory. Besides ISO 19115, the Dublin core metadata standard is also commonly used for spatial information, although it is a general purpose standard, which has not been developed specifically for geodata.

Web Service Interoperability

Web services [see GIS Web Services] enable loosely coupled service oriented architectures that provide Internet-based access to spatial data stored in remote databases. They allow for the execution of distributed geoprocessing functionality such as the online computation of standard GIS operations. In addition to standards for the formatting of the transferred data, Web services require standardized interfaces for the communication with these services. The OGC has developed a number of standards for geospatial Web services, with the most widely adapted being the Web Map Service (WMS) and Web Feature Service (WFS) specifications for the retrieval of raster and vector data, respectively. Further specifications cover advanced functionality such as geodata processing (WPS), sensor observation (SOS) or location services (OpenLS; see OGC 2003 for a complete overview). OGC specifications define Web service interfaces by specifying the formats for requests and responses. This implementation-

independent approach allows existing proprietary Web services to be subsequently equipped with an additional OGC compliant interface. Such a mapping is especially important for the integration of existing services into SDIs and follows an approach that has proven useful on the technical level: for a user, it is sufficient to know the interface, such as a power outlet or a WMS interface, and the corresponding interactions. It is then irrelevant how the electric power is generated or how a map tile is composed to make use of the interface. At the same time, this approach allows developers great latitude in the actual implementation of the services.

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See also Semantic Interoperability; Open Geodata Standards; Open Geospatial Consortium (OGC); GIS Web Services; Spatial Data Infrastructures

Further Readings

International Organization for Standardization (ISO) (1993). ISO/IEC 2382-1:1993 Information technology – Vocabulary – Part 1: Fundamental terms.

Open Geospatial Consortium (OGC) (2003) OGC Reference Model Version 0.1.3

Y. Bishr (1998) Overcoming the Semantic and Other Barriers to GIS Interoperability. *IJGIS* 12(4): 299-314.