HL7 and Spatial Interoperability Standards for Public Health and Health Care Delivery

Esri, 380 New York St., Redlands, CA 92373-8100 USA
TEL 909-793-2853 • FAX 909-793-5953 • E-MAIL info@esri.com • WEB esri.com

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HL7 and Spatial Interoperability Standards for Public Health and Health Care Delivery

An Esri White Paper

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Executive Overview

Health Level 7 (HL7) in decision support—especially in health care delivery and emergency public health response—has gained incredible importance. Recent events, such as the unintentional spread of severe acute respiratory syndrome (SARS), the devastation caused by Hurricane Katrina and the Indian Ocean tsunami, and the global threat of avian influenza, have increased the awareness that a lack of data interoperability is a major problem. In addition, numerous other disease outbreaks that are geographically relevant—such as *Legionella,* dengue fever, West Nile virus, and hantavirus—have exposed flaws in the ability of public health, animal control, emergency response, and health care delivery organizations to share critical data resources in a timely and efficient manner. Many public health authorities are now developing sophisticated information systems that will monitor and surveil the health of an entire nation's people, animals, and food supplies. All too often, many of these systems are relying on episodic data gleaned from the various transactional clinical systems of health care and veterinary providers without accurate geographic representation; thus, most health data collected from many of these sources has inaccurate geographic references, which inevitably compromises the entire decision chain.

More recently, the high level of interest in creating electronic health records has many nations investing in eHealth on a broad scale and, in many cases, across geopolitical boundaries. In addition to the many challenges to find solutions for system interoperability, data interoperability is also involved. One of the most critical challenges of a borderless health record is the ability to share accurate geographic references easily. The desired outcome of this interoperability is to create a standard frame of reference that facilitates decision making and cooperation by promoting the interoperability of geographic information.

In addition to addressing the above, this paper will describe the new HL7 Common Message Element Type (CMET), A_SpatialCoordinate, now available to the health community worldwide, and how the use of this improved geographic standard inside HL7 will help improve the spatial interoperability of health data across all public health authorities as well as between health care providers such as hospitals, clinics, physicians, and emergency responders.

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Introduction

Geographic information systems (GIS) consist of a powerful combination of analytic methods and computing technologies that facilitate spatial analysis and visualization of tabular information. Spatial analytic techniques, such as proximity estimations and cluster analysis, are built on statistical methods that incorporate distance and direction measurements to generate spatially accurate maps and graphic reports. Hospitals, health systems, providers, and public health agencies increasingly use GIS as a tool for understanding population health and program planning and generating performance measurements for use as key components of management information systems such as dashboards. Additionally, eHealth initiatives can leverage GIS to achieve disease surveillance and outbreak detection objectives while adding functionality that supports analysis of data from bordering jurisdictions.

Success with the use of GIS is dependent on the availability of spatial data (or data that can be easily converted to spatial data). Spatial data is readily usable within a GIS and refers to data that includes geographic elements, such as latitude and longitude, as well as accuracy information in the form of metadata elements. Representing the GIS community, Esri, the leading manufacturer of GIS software, began working to assess the ability of the Version 2.x standard to message spatial data to ensure that the Version 3 standard would accommodate data elements consistent with international standards for geographic data representation as well as GIS best practices among hospitals and public health agencies. Working from within the Public Health and Emergency Response Special Interest Group (PHER SIG), Esri joined senior HL7 modelers to generate use cases that would serve to build consensus on spatial data content requirements. The result of this effort is A_SpatialCoordinate.

Discussion

The Case for Place

GIS is useful as a tool for data-level interoperability and can bring data from many sources into a common environment. With the presence of *key fields* in traditional relational database management systems (RDBMS), tables may be joined and related, but the key field must be present and typically takes the form of an identifier that may link data from disparate systems. Geographic coordinates can be used as both primary and foreign keys, which allow any two datasets that have been *georeferenced* (assigned latitude and longitude coordinates) to be displayed, queried, and analyzed within a GIS environment. The unique power of GIS is that *everything has location*—patients, facilities, exposure pathways—so all spatial data has a key field within a GIS. Any georeferenced data can be compared with, superimposed on, or analyzed with any other data.

To better understand the need for spatially accurate information and the importance of location, consider the following scenario:

"A disease outbreak has been confirmed by the public health authorities, and now mitigation procedures are initiated. Selected immunizations must be planned, quarantines must be enforced, and progress on containing the outbreak must be communicated to the public. Community leaders need assurance that the data on which they make decisions and present findings to the community are accurate and reflect the real situation. Community health leadership needs to perform both risk assessment and risk communication. This type of analysis depends on accurate, standards-based, geographic information that supports analytic results at a high level of confidence."[1]

In addition to system-level interoperability, this situation demands the capacity of different agencies and participants in data exchanges to perform spatial analysis consistent with organizational objectives. Hospitals, clinics, and laboratories would serve public health decision making by capturing geographic data elements as part of their business process, thus enabling immediate import into GIS-based outbreak management systems. Public health authorities could then support response by local assets by making the results of their spatial analyses available in a standardized messaging format.

Note also that population-level summary measures are limited in their ability to support decision making at the local level; a general sense for patient location is insufficient to support the coordination and mobilization of local assets. They may influence policy development and the direction of a national agenda, but in the context of outbreak management, the ability to share highly accurate spatial information allows the precise allocation of resources. Furthermore, spatial analysis with electronic medical records containing precise geographic data elements can result in a greater understanding of the environmental context for disease transmission and help identify the environmental factors that may impact population health.

Spatial Data Interoperability

From the GIS perspective, data messaging represents an innovative model for data exchanges—traditionally, the ability to share GIS data depends on the existence of common database models. As a result, many industries that use GIS have worked for years to develop standardized *geodatabase* models that allow the easy import and export of spatial data. In most market spaces, this strategy has proved effective. Few markets, however, share the internal diversity of health and human services. This may help explain some of the barriers encountered in the creation of a widely accepted health geodatabase model for use as a template within the variety of health market domains served by GIS. The functional requirements of an information system at a public health department will never match the requirements of hospitals, clinics, and laboratories; database structures that support these areas are equally diverse. Ensuring the interoperability of spatial data by incorporating spatial content standards into the HL7 Reference Information Model makes spatial data elements available to all HL7 implementers and enables the development of HL7-based GIS services.

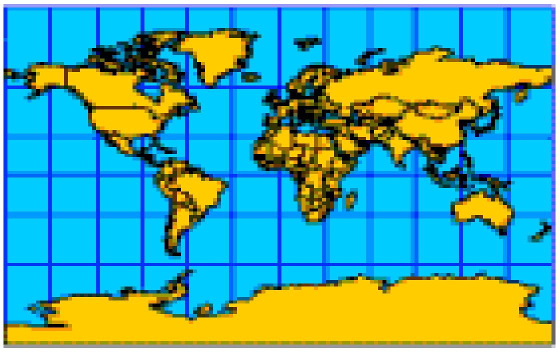
The case for interoperability is driven by the need for neighboring communities, and even nations, to be able to collaborate on public health issues. A health record that includes geographic information is in a sense borderless as the presence of geographic data elements allows that record to be compiled into customized spatial analysis systems. Since diseases know no boundaries, the ability of neighboring localities to share and interpret spatial analysis is essential. As a result, many national and international initiatives exist to help standardize the way geographic information is stored. The Federal Geographic Data Committee (FGDC) in the United States is a corollary to the international ISO Technical Committee 211, both of which work within the context of the Open Geospatial Consortium, Inc. (OGC), a group dedicated to making spatial data independent of platform. In developing the Spatial Coordinate Common Message

[1] Davenhall, W. F., "Assuring Geographic Data Accuracy in the Electronic Health Record (EHR): The Importance of Geographic 'Location' in the EHR" to the Office of the National Coordinator for Health Information Technology, November 8, 2005, Washington, D.C.

Element Type, PHER SIG looked to the Spatial Data Transfer Standard (SDTS) developed by FGDC for guidance.

Spatial Data Content

Geographic coordinates (latitude, longitude, and elevation) are collected using specific mathematical algorithms that correct local geometry from the nonspherical earth. These algorithms, termed *projection systems,* describe the mathematical conditions under which a spatial data point was collected.



Projection Systems: The Three-Dimensional World Represented in Two Dimensions

Without this projection information, the accuracy of a location would be impossible to determine. The potential use of the data would then be in question. Regional and national health statistic generation requires less positional accuracy in the source data than do outbreak management systems. The required accuracy is thus defined by the business use cases: Routing emergency services requires the most accurate information; in an ideal situation, this would perhaps even mean the precise location of the entrance to a building, as opposed to the building center. Public health system performance evaluations can be done using less accurate data—summary measures may simply be tied to national or regional geographies. The ability to document the mechanisms by which geographic data elements are appended to an electronic health record in the form of geographic metadata is therefore essential to correct interpretation and application of the data.

Spatial data is collected mainly in two ways: by use of a Global Positioning System (GPS) device or by geocoding, a process by which an address is assigned geographic coordinates. Both of these methods may be more or less accurate depending on the specific procedure used. In general, coordinates derived from GPS devices are more accurate, but geocoding technology is quickly catching up and represents a very cost-effective way to enable legacy data for use in GIS.

GPS devices vary in accuracy, as do the methods for data collection. Accuracy may range from +/- 10 meters (~30 feet) or greater to submeter (<3 feet) using local correction techniques. Depending on conditions and the device used, accuracy can even be improved in postprocessing. The ability to express information about the mechanism of GPS data capture is therefore very important.

Geocoding systems are quite common and are available in the form of stand-alone applications, server-based modules, and Internet services. They ingest address data and compare that data with standardized geographic reference databases created from postal information and the digital capture of road locations. Addresses are first standardized (street names and abbreviations are corrected and verified), then compared with the reference data; when a match is found, the geographic data elements from the reference database are appended to the original record. The systems are designed to match addresses in a tiered manner by identifying the various components of addresses: city names, counties, states, ZIP Codes™, and so on. They will typically append geographic coordinates to most records, even when an address-level match is not possible, and will output a match code, which signifies the level of accuracy of the coordinates. An address-level match is more accurate than a match to a ZIP Code, which is likely more accurate than a match to a county.

To be valuable to the end user, a spatial data messaging standard must therefore accommodate the various ways spatial data accuracy is documented. If the data is collected using GPS, perhaps the device information should be included as metadata; if the data is geocoded, the metadata should include a match code.

Messaging Spatial Data

Prior to the creation of A_SpatialCoordinate, a location description or geographic coordinates might have been included in a Place.gpsText string variable, yet this format left open the possibility that spatial data might be used incorrectly. In its effort to refine the standard, PHER SIG began by first developing appropriate use cases for the transfer of spatial data and identifying the critical components of geographic information such as that specified by SDTS.

The following graphic depicts the way geographic coordinates are associated with a place.

Associating Coordinates with a Place

A_SpatialCoordinate replaces the Place.gpsText string and contains three new class codes:

- Position—The physical location of an entity as a set of coordinates based on a reference coordinate system
- PositionCoordinate—The set of two or more numerical values used to determine the position of an entity in a space defined by a reference coordinate system
- PositionalAccuracy—The degree to which the assignment of the spatial coordinates based on a matching algorithm by a geocoding engine against a reference spatial database matches actual values[2]

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[2] Case, James T., Add Act.Class codes for Position, Proposal Recommendation for HL7 RIM Change (ID PHER06-02), March 2006.

Conclusion

Standardized data messaging facilitates interoperability between health information systems regardless of database models employed by individual health care enterprises. The GIS community is looking forward to further interaction with health data standards development organizations such as HL7. The potential HL7-compliant web- and server-based services that make spatial analysis functions available to health information systems are now in development and will enhance the analytic capabilities of all HL7-based systems.

About Esri

Since 1969, Esri has been helping organizations map and model our world. Esri's GIS software tools and methodologies enable these organizations to effectively analyze and manage their geographic information and make better decisions. They are supported by our experienced and knowledgeable staff and extensive network of business partners and international distributors.

A full-service GIS company, Esri supports the implementation of GIS technology on desktops, servers, online services, and mobile devices. These GIS solutions are flexible, customizable, and easy to use.

Our Focus

Esri software is used by hundreds of thousands of organizations that apply GIS to solve problems and make our world a better place to live. We pay close attention to our users to ensure they have the best tools possible to accomplish their missions. A comprehensive suite of training options offered worldwide helps our users fully leverage their GIS applications.

Esri is a socially conscious business, actively supporting organizations involved in education, conservation, sustainable development, and humanitarian affairs.

Contact Esri

1-800-GIS-XPRT (1-800-447-9778)
Phone: 909-793-2853
Fax: 909-793-5953
info@esri.com
esri.com

Offices worldwide
esri.com/locations

esri

380 New York Street
Redlands, CA 92373-8100 USA

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