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MDIF - A Standard for Communication of Digital Map Data over Public Data Communications Systems

ABSTRACT

A number of efforts are under way world-wide to establish standards for communication of digital map data. All of these efforts are concerned with communicating a digital representation of a map. However, the comprehensiveness, level of complexity and type of data to be communicated differ between most of these developing standards. Almost all of these developing standards are concerned with communicating digital map data as record-oriented files of various degrees of flexibility on magnetic tapes.

This paper discusses work under way at the Ministry of Natural Resources, Ontario, Canada, towards development of a standard for communication of digital map data over telecommunications facilities using existing telecommunications standards.

The standard is based on The International Standards Organization's (ISO's) seven-layered architectural model for telecommunication's Open Systems Interconnect (OSI). The standard uses code extension techniques inherent in ISO 2022-1982 established by the CCITT (International Telegraph and Telephone Consultative Committee) and is being designed to encourage "blind interchange", that is, to allow communication of digital map information without the need for detailed negotiations between the sender and receiver concerning the capabilities required to display, communicate, sort or otherwise process the digital map data.

INTRODUCTION

Standards are the basis upon which society builds its infrastructure. This is particularly true in the areas of communications, transportation, and commerce where it is necessary for people to interact with each other. The more general the standard, the more important it is and the wider its applicability.

King James of England established a standard for the width of cart wheels. This ensured that all carts fitted the double rut "roads" of renaissance England and resulted in a blossoming of trade across the country. What is happening today is similar; we are specifying standards which define "electronic highways" which permit the flow of all forms of information. This will accelerate the formation of the information society. The unprecedented growth and development in the demand for digital mapping data and information makes it an important form of information which should be formatted in such a way that it may be communicated over public data communications systems, that is, its "cart wheels" should fit the electronic highways.

As telecommunications requirements have become more elaborate, so have the standards that govern the interchanges which constitute this communication. In order to harmonize the development of communications standards, work has progressed in the International Standards Organization (ISO) to develop a model for Open Systems Interconnection (OSI)[1]. This is the standard upon which public data telecommunications services are now and will continue to be based. The principal purpose of OSI is to separate the communication of information from its method of encoding or its use in a particular application. In alignment with OSI, various data syntaxes have evolved for coding text and pictorial information.

In order to define a standard for the communication of mapping information over public communications facilities, one should build upon existing standards such as the OSI-defined communications standards and standardized data syntaxes such as the American Code for Information Interchange (ASCII)[8] for text and the North American Presentation Level Protocol Syntax (NAPLPS)[9] for graphics information. This means that mapping data can be easily interpreted by conventional data processing and data terminal equipment. This contrasts with specialized or manufacturer-dependent standards which are limited to a particular class of manufacturer's equipment and thus a particular audience for communications.

By building upon the principles of OSI, mapping data can be kept independent from the media upon which it is carried. Any type of transmission media, such as magnetic tape, disc, and private or public communications facilities, may be used without altering the format of the data.

The following sections define the principles, structure, coding method, and syntactic description for a standard for the communication of mapping data called the Map Data Interchange Format (MDIF) being developed by the Ministry of Natural Resources, Ontario, Canada. This proposed standard is built upon existing telecommunications standards and is flexible enough to be usable globally in a wide variety of applications.

PRINCIPLES

The purpose of the map data interchange format is the specification of a standardized method of encoding map data for communication. The intended range of applications of this standard is broad. It is intended both for the professional use of mapping agencies as well as the dissemination of information to industry and the public in electronic form. Such a format must be flexible enough to accommodate the communications requirements or needs of various applications such as:

- the communications of mapping information from data capture sources (digitizing facilities) to mapping agencies;

- the intercommunications of map information between mapping agencies;

- the distribution of map data to other industrial, institutional, and public sector users such as municipalities in electronic form;

- making available electronic map information to the public.

The objective of the proposed Map Data Interchange Format standard is to provide a machine-processible communications format for map data which permits:

- independence from the transmission media
- blind interchange of data
- meaningful defaults on simple terminals
- data transmission efficiency
- accurate representation of data
- English, French, and other language text
- stability by being a public domain standard

MDIF will provide the capability to comprehensively describe a map by including formats for positional, graphical, attributional, and topological data as well as providing a means to easily extend the standard to cover new other forms of information.

MDIF provides rules for a "blind interchange" of digital mapping data between transmitting and receiving equipment. The concept of blind interchange is of central importance. The mapping information is defined independently of context so that it may be communicated without the need for negotiations between the sending and receiving entities. The same format of data is sent regardless of its intended use. Terminals or receiving computers can interpret those portions of the data which apply to their particular applications. It is important to avoid negotiation over the format of the data in order to eliminate the need to reformat the data for communications with each type of receiving computer or terminal. While it may be efficient for two identical computer systems to communicate information in terms of their own internal binary representation of numbers, this eliminates compatibility with other systems with different internal architectures. Reformatting of data introduces a significant processor load for the communicating devices and should be avoided.

Blind interchange is also important because it eliminates the need to manage different terminal or receiving computer "profiles". Because of the richness of mapping applications, without a single unified standard it is conceivable that hundreds of variations on a mapping data format would exist. The capability to support blind interchange permits an upward compatible family of terminals or data receivers to exist.

MDIF is a data format intended to communicate the positional, graphical, attributional, and topological content of maps. Some or all of this information may be used in any particular map definition. A receiving device such as a host computer system may interpret all of the MDIF coded information while a simple display-only terminal may be interested in only the graphical component. By making use of the standardized code extension techniques defined in the ISO 2022[11] data coding standard, MDIF can be easily extended to include formats for other types of information.

Information would be structured in such a manner that a meaningful default interpretation of the information is possible on simpler terminals. In particular, a simple display-only terminal can present the textual attributional data and/or the graphical data without interpretation of the application structure for simple presentation-only uses.

An intelligent terminal, such as a personal computer, can perform minor interpretations or computations upon the data so that enhanced pictures can be presented. Specific attributional information can be taken into account. For example, this may be of particular use in providing mapping information to municipalities (local governments) in electronic form.

A more sophisticated interpretation of all of the information, including topographical and transformational information, can be performed by a host computer. The interpretation may involve geographically related data bases which are under the preview of mapping agencies or other professional users.

The map data interchange format must be efficient to reduce the volume of data which needs to be communicated. As such, it is necessary to use a data syntax which packs co-ordinate and other numerical information into a small number of bytes while retaining the capability to specify these values to various levels of precision.

It is also necessary for a map data interchange standard to be stable and in the public domain. This is the difficulty encountered with manufacturer-defined "standards". A public standard undergoes an open review procedure and is maintained by a broadly represented committee. A manufacturer's interface specification is under the control of the manufacturer and may be updated at any time without particular regard for the applications in which it is used. Therefore, it is important that MDIF is defined based upon adopted national and international telecommunications standards, and that it be reviewed and maintained in the public standards forum.

RELATIONSHIP TO COMMUNICATIONS STANDARDS

MDIF is based upon existing data communication and presentation standards. Conventional telecommunications facilities or data processing media may be used to transport information formatted in terms of MDIF.

The function of communicating structured information for mapping applications can be separated into two parts: the application structure and the supporting data syntaxes. The application structure defines various types of record formats to carry different components of the map description. For example, textual information will be coded in the ASCII data syntax. However, the manner in which it will be interpreted is dependent upon the MDIF record format defined by the application structure. This is analogous to describing a postal address using the conventional alphabet of letters and numerals while at the same time conforming to a higher-level set of application rules which state, for example, that the postal code should be on the third line of a specific form. The coding of the "alphabet" and the format in which it may be used are separate specifications in MDIF.

The data syntaxes that will be in MDIF are:

- for the coding of textual information:

  the ASCII code table, along with the standard supplementary code table, for accents and special characters used in French and other languages.

- for pictorial information:

  the NAPLPS data syntax.

- for numeric data formats, delimiting codes, and other mapping-specific data coding:

  a specialized code table of Map Description Instructions (MDIs) specially designed for MDIF.

- for raster-defined, pixel-oriented cell array data:

  standard facsimile or photographic coding schemes may be used. Such data syntaxes are currently under development in ISO. This type of coding is reserved for further study.

APPLICATION STRUCTURE (SYNTACTIC DESCRIPTION)

The map syntactic description is broken down into sub-components. The description of each of these sub-components may themselves be broken down into sub-sub-components. This form of description may be recursive; that is, a sub-component may contain within its definition an invocation of itself. For example, as shown below, a digital map may contain one or several independent map definitions, each of which deals with a "patch" of a map.

The syntactic description that follows is defined in terms of the International Standard for the Specification of Telecommunication Formats, the ISO Abstract Syntax Notation (ASN.1)[10]. Each syntactic description record will be encoded in one of the data syntaxes identified earlier.

Th components of the syntactic description marked with an asterisk "*" will be implemented at a future date.

The description of a Digital Map begins with a Header Definition in which all of the administrative and global information about a map is presented. Following the header there may be one or more Map Definitions.

A Map Definition defines a segment of a total digital map termed a "patch". Each patch is itself a sub-map and may have a different projection from other patches composing a total digital map. Map Definitions may be taken separately or combined into an overall map. Typically, a map would consist of a single large patch, however, in larger scale maps where the projection changes on different portions of the map, for example, near the pole, different patches may be combined. Another use of patches would be to include inserts such as a sub-map of Hawaii or Alaska on a map of the continental United States, or a detailed chart of a bay on a larger scale chart of a coast. Also a set of related maps may be defined as patches of a larger composite map.

A number of patches, which are positioned to cover the same area, may be considered as overlays specifying a composite map. Thematic information may be overlayed onto a base map in this manner or information from different sources may be overlayed. The order in which overlays are built up, is the temporal order in which they are specified.

The definition of a map is divided into several sub-sections, each of which addresses a different portion of the information required to define a map. Some of these sections such as the Transform and Feature definition are mandatory, whereas other of these sections such as the Symbolized Map Definiton are optional, although they may be required in certain applications.

```
Digital-Map      ::=  Map-Header Map-Definition

Map Definition   ::=  Map-Sub-Header
                      Transform-Definition
                      Feature-Definition
                      Segment-Definition
                      Topological-Definition
                      Symbolized-Map-Definition            *
                      Other-Format-Defintion               *
                      Map-Definition | null
```

Structure of Map Header

The Map Header contains that information which identifies a particular Map and the context in which it is defined. It also defines those parameters which are global to the entire map. General administrative data such as that which identifies the number of the map, the version of the coding format, etc. are contained in the header.

```
    Map-Header   ::=  General-Admin-Section
                      Sub-Admin-Section
                      Quality-Section                      *
                      Security-Section                     *
                      Attribute-Init-Section               *

       General-Admin-Section ::=  Map-Number
                                  Format-Version
                                  Update-Indication        *

       Sub-Admin-Section     ::=  Admin-Group
                                  Data-Set-Iden-Group
```

```
Admin-Group            ::=  Map-Name
                            Issue-Date
                            Revision-Date
                            General-Comments

Data-Set-Ident-Group   ::=  Map-Boundaries
                            Geodetic-Datum
                            Reference Ellipsoid
                            Sounding-Datum            *
                            Vertical-Ref-System       *
                            Linear-Measurement-Units
                            Angular-Measurement-Units
```

Structure of the Map Definition

The Map Definition contains that information which describes the actual map being communicated. It is broken down into several sub-definitions, each of which addresses a division of the total definition. These divisions are the:

- o Transform Definition
- o Feature Definition
- o Segment Definition
- o Topological Definition
- o Symbolized Map Definition
- o Definition of other Formats

Transform Definition

The transform definition describes the relationship between the co-ordinates used to define a map and the real world co-ordinate system.

```
Transform-Definition  ::=  Projection-Item
                           Location-Item

   Projection-Item     ::=  Projection-Type  P-Parameters

      -- The definition of the projection item is mandatory
         for a single map definition or for the first patch
         of a composite map definition.  For the second and
         subsequent patches of a composite map definition the
         projection item is optional and the projection
         defined for the first map definition within the
         composite map is used.  If no projection is defined
         at all then a syntactic error occurs.

   Location-Item     ::=    Trans-Type-1
                          | Trans-Type-2
                          | Trans-Type-3
```

```
Trans-Type-1      ::=    X-Translation  Y-Translation
                         Scale
                         Rotation

Trans-Type-2      ::=    X-Translation  Y-Translation
                              Mat-11    Mat-12
                              Mat-21    Mat-22

Trans-Type-2      ::=    X-Translation  Y-Translation
                              Mat-11    Mat-12    Mat-13
                              Mat-21    Mat-22    Mat-23
                              Mat-31    Mat-32    Mat-33
```

Feature Definition

A map is described in terms of its constituent features. Each feature is numbered so that it may be referenced. Each feature also contains a specification of the location and type of the feature, as well as a reference to the attributes associated with that feature type. The nature of the attributes are defined by the feature type. Additional thematic attributes pertaining to a particular use of a map may optionally be associated. For example, in a forestry application the number and type of trees may be important thematic information not normally associated with a cartographic map.

```
Feature-Definition  ::=  Feature-Header  Feature-Items

   Feature-Header      ::=  Feature-Type-Table-Reference1
                            Thematic-Attribute-Reference    *
                            Feature-Data-Declaration

   Feature-Items       ::=  Feature
                            Feature-Items | null

       Feature             ::=  Feature-Number  Feature-Location
                                Feature-Type    Feature-Attributes
                                Segment-Number  Containment-Indicator
                                Feature-Name

         Feature-Location    ::=  F-Reference-Position  F-Limits

             F-Limits            ::=  F-Min-Max | F-Strip |
                                      F-Min-Max F-Strip

         -- Each feature is identified by a feature type which takes
            on a particular set of attributes.

         Boundary-Reference  ::=  Segment-Number  Boundary-Reference
                                  | null
```

[1] The Feature-Type-Table-Reference will contain the Topographic Codes and Dictionary of Topographic Features of the National Standard for the Exchange of Digital Topographic Data, EMR, Government of Canada [14].

Segment Definition

The segment definition defines the geometric shape of the various boundaries of features. These segments are coded in terms of points, lines, arcs, splines, polygons and occasionally other drawing primitives defined in the supporting data syntaxes.

```
Segment-Definition  ::=  Segment-Entity
                         Segment-Definition | null

   Segment-Entity       ::=  Segment-Number
                             Segment-Type
                             Segment-Boundary

      Segment-Type          ::=  Virtual-Segment
                                |Real-Segment
```

Topological Definition

The spatial relationships between map features are specified by the topological definition. Such information as adjacency and interconnectivity is obvious to the reader of a map, however, it may be quite tedious to extract from the segments defining the boundaries of the various features. The topological definition section describes the connectivity of features in terms of control points (or nodes).

Nodes represent the end positions of linear features such as lines as well as the points of intersection of features such as a common vertex shared between a polygon and a line intersecting it. An entire map may be described in terms of mathematical graph theory. Every linear feature is described in terms of reference nodes carrying explicit direction and left/right connotation. Multiple disjoint "graphs" may be described in order to accommodate situations such as containment or overlap.

```
Topological-Definition  ::=  Topo-Entity
                             Topological-Definition | null

      -- The Topological Defintiion is optional and may be
         entirely null.  If suplied it consists of a sequence
         of Topological Entities.

   Topo-Entity              ::=  Segment-Number
                                 Spatial-Containment-Indicator
                                 Begin-Node-Numb  End-Node-Numb
                                 Feature-on-Right Feature-on-Left

      -- Feature on the right and feature on the left are with
         reference to the beginning node to the end node
         direction.
```

Symbolized Map Definition

A symbolized map is a dressed view of map information which has been cartographically enhanced and is suitable for dissemination to an end user. Features may be drawn using specific symbols or drawing styles. For example, streets may be drawn with visible widths rather than a centreline representaiton. Considerable further study is required in this area and a symbolized map definition is not included in the interim MDIF format.

Other Format Definition

Other representations of map information may be included along with a map definition usually as thematic overlays. For example, weather radar data may be overlayed on top of a map even though this weather data might be encoded in a facsimile-like format. Since the overall interchange format is structured according to the international standards for presentation coding, it is possible in the future to accommodate any such associated presentation format. Of particular interest are the presentation standards emerging for the presentation of pixel-based "photographic" or "raster" information to handle satellite or radar imagery.

Considerable further study is required in this area and a definition for other data formats is not included in the interim MDIF format.

CONCLUSION

The development of MDIF at the Ministry of Natural Resources, Ontario, Canada, represents a new dimension in the exchange and dissemination of digital map data and information. MDIF will be a single comprehensive standard which will accommodate the requirements of interchanging digital map data between agencies as well as for communication and presentation of digital map information to private, industrial and public users (e.g. to computer terminals aboard emergency vehicles).

However, a standard like a prophet, gains its power from the faith and number of its believers. The Ministry of Natural Resources hopes to work closely with other government agencies and the mapping industry in an effort to arrive at a standard that will be suitable and therefore adopted by the community at large.

This paper has summarized MDIF for which detailed information can be found in the following reports:

Map Data Interchange Format (MDIF), Ontario Ministry of Natural Resources, Toronto, Ontario, Canada, 1985.

Syntactic Structure for Map Data Interchange, Ontario Ministry of Natural Resources, Toronto, Ontario, Canada, 1986.

REFERENCE

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13. Presentation Transfer Syntax and Notation - Message Handling Systems, CCITT Recommendation X.409, 1984, Malaga, Torremolines.

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