7 Design of Multimedia Mapping Products

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7.1 Introduction

Design is a complex process. The design of a conventional map-based product involves the cartographic abstraction (Muehrcke 1978) processes of dimensional transformation (scaling and projection), selection and generalisation and various graphic and structural design processes including symbolisation, visual composition, figure-ground and hierarchical organisation and content arrangement (Bertin 1967; Dent 1993; Keates 1973; MacEachren 1995; Robinson *et al.* 1995; Wood 1968). Conventionally, this process also involves a number of compromises due to design constraints such as map scale, presentation format, area coverage and the degree of geographical complexity required in a map-based product. This complex process is made more complex in a multimedia environment by the addition of a greater number of design constraints, a greater and more varied quantity of media with which to work, and the incorporation of tools to enable users to interact directly with maps and map-based information. This chapter aims to simplify this complex process by discussing an approach to designing multimedia map-based products.

The approach to designing multimedia map-based products discussed in this chapter is equally applicable to both discrete (e.g., CD-ROM) and distributed (e.g., WWW) mediums of presentation. At the same time it should be recognised that given the current technological limitations associated with presenting and providing access to content via the WWW (i.e., limited bandwidth and modem speed), much of the design approach discussed in this chapter is far more easily achieved when using discrete media for distribution.

This chapter focuses on the design of discrete multimedia map-based products that communicate spatial, thematic and temporal information about the geographical environment by exploiting maps as the primary, yet not exclusive, source of information. The concept of the map has been extended in more recent years and is approaching a stage of re-evolvement with technologies such as virtual reality and research into visualisation promising new ways of representing information. Despite this, currently the map, as conventionally defined, remains the primary tool for the presentation of spatially definable content, particularly from a publication perspective. It is recognised that this focus on maps as they are more conventionally defined, as graphical representations, and on multimedia map design as an extension of existing map design techniques, is perhaps an interim approach.

7.1.1 Concepts of Map-Based Access

Map-based access enables users to access multimedia content relative to spatial locations via map symbols that have been defined as ‘hotspots’. It is important to make a distinction between two types of map-based access:

1. Map-based access in which maps are used as ‘Content Organisers’. As content organisers, maps visually organise content using a spatial metaphor. Multimedia content is not designed to aid in the decoding and interpretation of maps, rather, maps are used to arrange content in an easily accessible manner. This type of map-based access is intuitive for information systems for such applications as tourism (Mogorovich *et al*. 1992; Panagopoulou *et al*. 1994; Schewe 1993). Map-based access has also been used to organise content that is not conventionally spatial in nature (Hodges and Sasnett 1993). In fact, as a content organiser, map-based access has emerged as a relatively common means of access in multimedia products and web-based sites.
2. Map-based access in which multimedia content is intended to support and enhance map decoding and interpretation. This type of map-based access is less common but it is anticipated that this will change. This is particularly so given the interest of cartographic researchers in finding new ways to use animation, digital and multimedia techniques to increase the ease with which users use maps.

7.1.2 Presentation and Structure Characteristics of the Multimedia Environment

Multimedia products and print-based products use distinctly different information presentation and information structure techniques given the characteristics of each environment of use. Multimedia mapping products are dynamic, interactive, associatively accessed, modifiable and functional products that use a synthesis of audio and visual media for cartographic representation. Product design must take into account the requirement to seamlessly integrate multiple media and to enable direct user interaction with information. Product design must also incorporate the use of dynamic and responsive environments of display and increased functionality enabling analytical and manipulation capabilities. Information structure in a multimedia environment is influenced by the limitations imposed by a computer screen display environment. Restrictions in screen display size and resolution require that manageable chunks of information are used. Since random and associative access are possible, consideration must be given to the manner in which content is arranged in organisational structures, and the way in which access mechanisms are provided. In addition, meaningful relationships between content must be constructed based on information, rather than media, content. This chapter discusses a design approach in accordance with these new information presentation and structure requirements.

7.1.2.1 The Hypermedia Paradigm

The ‘hypermedia paradigm’ (Maurer and Tomek 1990) refers to the application of the principles of hypermedia to computer applications or product construction. The concept of hypermedia is generally used to refer to the associative linking of chunks of information in large, active, networked systems such as the WWW (Maurer 1993; Parsaye *et al*. 1989). However, its underlying principles are also appropriate for the structure of information in multimedia products that do not necessarily represent large, active databases, and do not always enable entirely flexible access to content (Apple Inc. 1994; Parsaye *et al.*1989). Such products use the ‘hypermedia paradigm’ rather than the fully-fledged definition of hypermedia.

Hypermedia is an important concept in terms of the structuring of multimedia information. In a hypermedia environment, information is structured as a series of nodes (modules of information) that are connected according to active contextual relationships (associative links). These modules are usually, but not exclusively, complete pieces of information that can be viewed independently of other information (Ambron and Hooper 1988; Jonassen 1989; Shneiderman and Kearsley 1989). Landow (1991) contends that the very existence of links in hypermedia products and systems conditions the user to expect purposeful relationships between connected information. Based on this contention, the spatial environment of access created by using a map as an interface component, conditions the user to expect a purposeful relationship between the map point of access and the information displayed. As such, the hypermedia paradigm is integral to the concept of map-based access.

7.2 Components and Design of Multimedia Map-Based Products

This section provides a brief overview of the main components of multimedia map-based products that are structured according to the hypermedia paradigm. In this chapter, the term ‘object’ is used to refer to a node in the hypermedia environment of a multimedia map-based product. More correctly, and as part of wider research undertaken by the author of this chapter, the term refers to a node in an object-oriented product construction environment (Miller 1996). The multimedia map-based product is comprised of three primary components:

1. the Graphical User Interface (GUI);
2. a content-set; and
3. object links.

Although each of these components is briefly defined, the focus of this chapter will be on the GUI.

7.2.1 The Multimedia Map-Based Product GUI

The success of a multimedia product is determined primarily by its Graphical User Interface (GUI) (Apple Comp. Inc. 1994). Although content, the contexts within which content is used and the associations between content are also determining factors (Blum 1995), it is the GUI that enables product functionality, navigation and the visual display of content to be realised. The GUI is particularly important in multimedia map-based products given the use of map-based access and the fact that in many instances multimedia content and functionality is intended to support the map content. The multimedia map-based product GUI is comprised of two components: the map object (a responsive display construct that is the primary means of product control and provides direct spatial access to product content); and marginalia objects (referring to those objects that exist outside the bounds of the map object that incorporate display, access, navigation and interaction tools).

Every graphic presentation employs visual hierarchies that aim to guide the viewer’s eye across the display in a manner fitting to the content (McCleary 1981). The multimedia map-based product GUI requires a clear visual hierarchy in order to separate its component parts, both visually and conceptually. This can be achieved via the use of structured display viewers, a window or an area of the screen display that is distinct from all other areas (Blum 1995) and/or the use of graphic design variables such as colour. In fact, colour is becoming a ‘pseudo-standard’ for creating distinction between different components and content of multimedia and web-based products (Sather *et al*. 1997).

7.2.1.1 The Map as a Display and Product Control Construct

The map object is the key component of the multimedia map-based product and functions as both a product control and display construct. The map object is a composite object composed of a conceptual framework (‘map object model’) and a number of visual representations of this framework (‘map object displays’). Each map object is defined according to a distinct spatial coverage with its component 'map object model' storing a number of combinations of attribute values according to theme, timeframe and scale. Each combination of attribute values is associated with a ‘map object display.’ In order to construct a multimedia map-based product, each component map object display must represent an individual map (pre-created, dynamically generated or a combination of the two) whose design has been optimised according to a specific theme, timeframe and scale.

In the multimedia map-based product, every object has a relationship with the map object and the map object controls how each object is displayed and behaves. It acts as the product control construct, determining object behaviour in response to user interaction and controlling the relationships between objects in the product. As a visual display construct, the map object uses a ‘symbol-oriented’ structure (see Sect. 7.2.1.2) and a hierarchical arrangement of content to emphasise spatial locations, distributions and relationships. The symbol-oriented structure of the map object enables controlled access to multimedia content to enable the decoding and interpretation of the map object. All access is controlled by the map object relative to a specific spatial context governed by the spatial attributes of individual symbol objects and map object theme and timeframe. The map object and its associated components are displayed in Fig. 7.1.

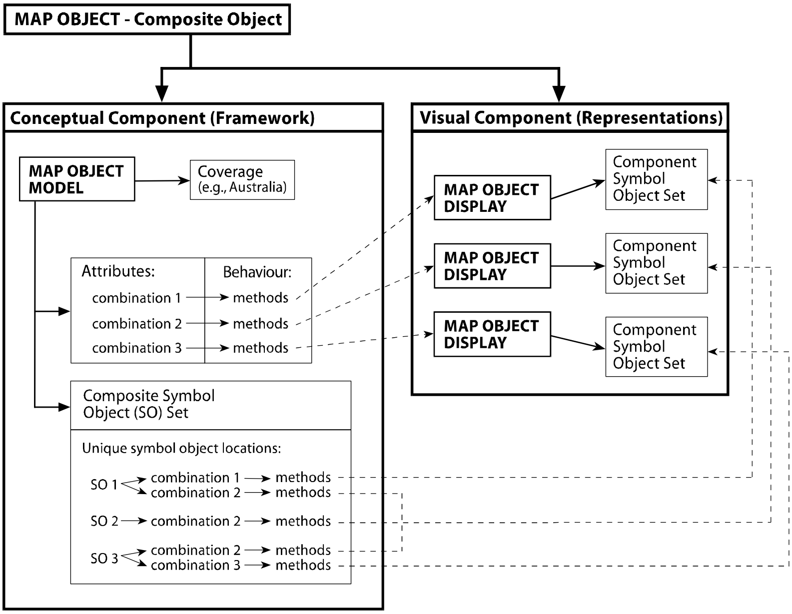

Fig. 1. The Map Object: The relationship between the 'map object model' and the component 'map object displays'.

'Scale-Sets'. Multimedia map-based products are publication quality products whose map content is optimised for display at a specific scale. Generalisation, symbolisation and other design components are specific to a certain scale in both conventional and multimedia map-based products. To avoid destroying map design components, it is not sufficient to merely enlarge or reduce a single map object display in a multimedia product. In order to ensure the map object is optimised for display at all the scales at which it may be displayed, it is necessary to create 'scale-sets' with each map in the scale-set optimised for viewing within a specific 'scale-range'. A 'scale-range' refers to the range of scales at which a map can be optimally displayed (Arnberg 1993).

Coverage Maps. Map object view and map object coverage are distinctly different in a multimedia map-based product. Kuhn (1991) defines view as the visual field that contains what a user sees at a specific point in time. Therefore, map object view refers to the portion of the map object coverage displayed at a point in time. In comparison, the map object coverage refers to the extent of the spatial information contained in the map object. In most instances this will exceed the available map object view area due to the current limitations associated with the environment of display (VDU display and resolution) (Wood 1993).

The synoptic effect is inherent to all conventional map-based products where maps can be viewed in their entirety and compared directly with other maps. The multimedia map-based product can not maintain this synoptic overview in the map object without increasing levels of generalisation in order to maintain legibility, which in many instances renders the map object content largely unusable. The lack of synopticity can be minimised by the use of a coverage map and a flexible map object viewer. To enable the user to locate the map object view with respect to the map object coverage, it is necessary to employ the use of a map that acts as a positional indicator. This is referred to as the coverage map. In addition, in order to provide a flexible map object viewer it must be possible to display multiple views of the map object coverage to enable regional and thematic comparisons.

7.2.1.2 Symbol Objects

Associated with each map object is a composite symbol object set. Each symbol object in this set has a unique location, and a number of associated structures and behaviours depending upon the map object attribute values of theme, timeframe and scale. Each map object display is also comprised of a set of symbols referred to as the component symbol object set, however, these are only visual in nature. The behaviour of each symbol in the map object display is controlled by its corresponding symbol in the composite symbol object set according to the attribute values of the map object. As such, each unique symbol object location has associated with it a number of different visual representations and behaviours according to theme, timeframe and scale (see Fig. 1).

Symbol objects in a map object display are of two types:

1. First Order Symbols – symbol objects that have a direct relevance to the map object theme. Symbols of this type have multimedia content associated with them that is intended to aid in decoding and/or interpretation. Controlled access is provided to this content via the map object. First order symbol objects represent the most visually and intellectually dominant symbol objects.
2. Second Order Symbols – symbol objects that contribute to the overall spatial structure of the map object. They provide the spatial framework necessary for the decoding and/or interpretation of the first order symbology. Whilst second order symbols are defined as objects

and may be responsive to user interaction, they do not have any associated content to which they provide access.

When integrated, first and second order symbol objects create spatial structure via visual hierarchies in the same way as the conventional map.

The visual role of symbology in a multimedia map-based product corresponds to that of the conventional map, however, while symbology in a conventional map is static and a means of display only, in a multimedia product symbology has extended functionality. Each symbol object is responsive to user interaction. In addition, each first order symbol object has associated multimedia content, that may or may not be intended to enhance map object decoding and interpretation. The associated multimedia content is arranged according to an organisational structure (see 7.2.3) based on the map object attributes of theme and timeframe and the specific symbol object location within a coverage. Each first order symbol object represents the parent node in an associative network to which other nodes are cross-referenced.

Each 'map object model' and its associated symbol object set is defined by the attribute of coverage, however, it is the attributes of theme, timeframe and scale that determine the specific visual structure and behaviour of symbol objects that are visible to a user. Each symbol object has an associated state and behaviour. Two mechanisms are used to enable symbol objects to function in the map object:

1. Display Mechanisms – these mechanisms control the visual appearance of a symbol object in response to user interaction and enable the incorporation of ‘self-describing’ symbols.
2. Access Mechanisms – these mechanisms are exclusively associated with first order symbol objects and control the access of multimedia content relative to unique symbol object locations.

Both mechanisms enable the incorporation of ‘user-notification stimuli’.

Self-Describing Symbols – The Embedded Legend. According to Blum (1995), icons in user interfaces, particularly multimedia interfaces, are not intuitive to every user. In many instances, the same can be said of map symbols. Most maps contain symbology that requires explanation in order to enable decoding and interpretation. Conventionally this has been provided by a legend, part of the map marginalia, requiring a visual comparison with the map content in order to decode the symbology (Robinson *et al*. 1995). In a multimedia map-based product, the symbol-oriented structure of the map object makes possible the concept of ‘self-describing’ symbol objects.

A ‘self-describing’ symbol provides its own descriptive information. As such, each symbol object in the map object has a unique legend associated with it. This legend is a component of the symbol object structure and remains hidden until exposed, if required, by the user. A ‘self-describing’ symbol also alleviates many of the problems associated with the limitations of computer screens as display devices for high resolution map data by enabling identification information to be displayed as needed rather than persistently. The activation of ‘self-describing’ symbols when using a multimedia map-based product can be the result of setting a mode of display (Armenakis 1993). Alternatively, ‘self-describing’ symbols can be an integral and persistent part of symbol object structure (Miller 1996). For example, descriptive information can be accessed by simply moving a mouse cursor over a symbol.

Self-describing symbol objects and the multimedia environment provide an opportunity to increase the detail and specificity of legend material accessible from individual symbol objects. For example, since a symbol object is self-describing, its legend content may be slightly different to that of another symbol object of the same graphic appearance. Therefore, legend content is spatially as well as thematically specific.

User Notification Stimuli. A user notification signal is an aural or visual signal, such as a change in symbol object colour or intensity (brightness). According to Lynch (1994), signals or ‘cues’ are necessary to provide feedback to users and are fundamental design features of graphical user interfaces. A key multimedia component is the ability to enable the dynamic presentation of content. Since symbol objects are dynamic and responsive to user interaction, each symbol object in the multimedia map-based product, encapsulates within its internal structure the ability to provide user notification for the purpose of indicating:

- the presence of an access mechanism or the status of a symbol; and
- a spatial relationship between itself and an information object.

A number of standard multimedia interface techniques have emerged as a means of indicating the presence of embedded content, or an access mechanism. Of these, cursor modifications are the most universally employed means of indicating the existence of ‘hidden’ information in multimedia products (Blum 1995; Michon 1992). Cursor modifications can be further extended to indicate the type of information that can be accessed (Blum 1995). For example, this may involve using a camera icon to indicate the presence of a photograph when moving a mouse cursor over a symbol object.

Modifications to symbol object appearance can be used to indicate both the presence of an access mechanism and a spatial reference between a symbol object and an information object. A direct manipulation interface is one that supports visibility of the object of interest (Shneiderman 1987). Since the multimedia map-based product represents a direct manipulation interface, it is necessary to ensure that symbol objects that have the users attention have greater visibility. This can be achieved by manipulating the conventional visual variables of the symbol object and/or via the use of dynamic visual variables (DiBiase *et al.* 1992; Köbben and Yaman 1995). Several cartographic multimedia products utilise user notification signals. Jiang *et al.* (1995) refer to the use of 'blinking' to attract user attention. Armenakis (1993) alludes to the use of user notification signals with respect to the *1:50,000 Topographic Map Application* in which 'double-clicking' on a road (for example) causes the road to be highlighted and information provided. Ishizaki and Lokuge (1995) refer to the use of opacity and transparency to create hierarchical relationships between symbols in maps based on a context.

User notification stimuli are an inherent component of symbol object structure and are visual and/or aural in nature. From a visual perspective, recent research on dynamic visual variables (Köbben and Yaman 1995; Wang and Ormeling 1996) can be applied to the construction of user notification stimuli. From an aural perspective, cartographic research on sound variables (Krygier 1994), and more generic research on sounds in the user interface (Blattner 1993), suggest that when combined with visual responses, sound can be effectively used as a means of user notification.

7.2.1.3 Marginalia – A Concept Extended

The concept of marginalia is extended in a multimedia map-based product. Conventionally, marginalia refers to information (graphical, image or textual) that exists outside the spatial bounds of a map and whose primary role is to aid in the decoding and interpretation of that map. In the multimedia map-based product, map marginalia shares the same primary aim, however, it is more varied and requires additional capabilities to support the decoding and interpretation of the map object. The multimedia map-based product contains three types of marginalia: spatial, manipulation and navigation marginalia.

Spatial Marginalia. Spatial marginalia are visually dynamic objects that are seamlessly and actively linked to the map object and may include scale, direction, geographic location and legend information. Being actively linked to the map object, any change in, for example, map scale or coverage is reflected in the spatial marginalia while it is also possible for the user to change the scale, orientation and map object view via the direct use of spatial marginalia. Despite the incorporation of 'self-describing' symbols, a legend should also be available on request for purposes where symbol object comparisons are necessary to facilitate interpretation.

Manipulation Marginalia. Manipulation marginalia enable direct interaction with the attributes of the map object. Many of these tools prompt a change in the values of map object attributes causing the map object display to respond accordingly. According to Asche and Herrmann (1994), interactive maps should provide zoom and scale controls to enable direct user interaction. Fundamental manipulation marginalia should also include panning functionality, view modification and, depending on the product, layer manipulation and search functions.

Navigation Marginalia. The standard multimedia product contains some sort of reference to the overall product content usually via content listings consisting of subject or theme headings. This provides the upper level structure of the product as well as a means of providing an overview of product content. In the multimedia map-based product, navigation marginalia function as a content overview that is displayed in conjunction with the map object as a component of the GUI. Coverage, theme and timeframe selectors, or navigators, should be persistently available as 'buttons', icons or pull-down menu structures to enable a user to change the attribute values (coverage, theme and timeframe) of the map object and therefore the current map object display. The attribute values of the coverage navigator are persistent within the product GUI since the range of coverages available does not change. In comparison, the map object attribute values of theme and timeframe are non-persistent. Different themes may be related to different coverages and different timeframes may be related to different themes. As such the theme and timeframe navigators are active. A sub-theme navigator may also be incorporated; this is controlled by the attribute value of theme and represents a means of content access (in addition to symbol object access to content). This enables the rapid access of specific information of interest, however, it is important that a spatial context is maintained by ensuring the spatial locations, distributions and relationships to which content relate are always visible within the map object itself (see Miller 1996 for a more detailed coverage). Depending upon the required functionality of the product, search tools should also be incorporated to assist user navigation and access.

7.2.2 The Multimedia Content-Set

The multimedia content-set refers to the content objects contained within the multimedia map-based product such as maps, photos, text, video and sound. A multimedia MBIP content-set is comprised of four types of content objects which have distinctly different roles:

- Direct Spatial Objects – referring primarily to map object displays and to other maps used as locality indicators and to illustrate spatial concepts or distributions;
- Information Objects – referring to the multimedia content used to assist in map object decoding and interpretation. Every information object has a spatial context;
- Functional Objects – referring to the visual objects used in the multimedia MBIP GUI. These include marginalia objects and other standard multimedia interface objects; and
- Aesthetic Objects – used only as a means of increasing the aesthetic appeal of a product.

7.2.3 Object Links and Organisational Structures

Object links are used to define relationships between symbol objects and information objects and between individual information objects. There are various types of object links, also referred to as associative links (Bielawski and Lewand 1991; Parsaye *et al*. 1989; Woodhead 1991). Miller (1996) discusses an approach to classifying links and thereby the relationships between information objects and the map object.

Organisational structure refers to both the ‘concept structure’ and ‘content order’ of information objects (Sikillian 1995). Concept structures connect objects according to a common semantic category and in a multimedia map-based product are used to create associations based on spatial context. Concept order refers to the order in which objects are accessed or the arrangement of objects. Therefore, organisational structure refers to the types of information objects to which a symbol object is referenced and the order in which these are presented during content access. Each symbol object in the map object has an associated set of information objects arranged in an organisational structure according to map object theme and timeframe and the unique location of the symbol object. Conceptually, a symbol object with a specific map object location may have a number of organisational structures associated with it according to different map object attribute values.

The organisational structures used in multimedia map-based products are highly structured in nature in order to guide access and user interaction (Asche and Herrmann 1994; Ormeling 1993), however, this does depend upon the requirements of the product. Generally, the aim is to convey a thematic and/or temporal structure, based on a spatial context, between linked symbol objects and information objects (Miller 1996).

7.3 Conclusion

Multimedia is a potentially powerful tool for geographical representation. It enables a greater quantity of a more diverse range of media to be used to increase the potential for the communication of spatial information. It also enables an interactive, dynamic environment in which a user can explore, manipulate and transform spatial information. This ability to incorporate such a wide range of media into map-based products can have a tendency to focus the cartographer's attention on issues other than map design. Map design still remains a primary means of spatial communication in a multimedia environment, particularly in the multimedia map-based product environment discussed in this chapter. Despite the potential that interactive three-dimensional spatial environments, virtual worlds, and the more immersive environments of virtual reality offer for representing spatially definable content (Jacobson 1994; Koop 1995), it can be surmised that the two-dimensional map, whether in hard-copy or multimedia format, will remain a dominant means of spatial representation given its ability to provide a succinct summary of spatial patterns and relationships within a coverage. It is at the development of multimedia products whose primary content is the two-dimensional map that this chapter is aimed. This represents a sub-set of the ever increasing field of multimedia cartographic design.

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