Design Guidelines for Digital Atlases

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Interestingly, cartography is one of the oldest disciplines, but it is also continuously in the forefront of disciplines to adopt and adapt current technologies (Koussoulakou 1999).

Introduction

In 1995, *Cartographic Perspectives* put forth an entire volume dealing with the issues of production, dissemination and use as related to electronic atlases. The impetus for the volume came from the success of two special sessions held on the subject: the first being sponsored by the International Cartographic Association (ICA) in 1993 and the second organized at the annual convention of ASPRS / ACSM in 1994 (Trainor, 1995). These papers can now be viewed as a snapshot of the state-of-the-art in electronic atlases in 1995. A review of the articles contained in that special issue reveal several important topics. First, in 1995 the tussle for allegiance to the various computer platforms (Dos, Windows, MacIntosh, Unix) was still an issue (Rystedt, 1995). In 2002, it would appear Windows has won that battle although dissemination across the Internet has made the matter (with regard to digital atlases) less significant. Dissemination, then, was a second major theme in 1995. Electronic atlases were still distributed primarily on digital hardcopies with the CD-ROM being the preferred method. Several of the authors predicted that the Internet had the potential to be as significant as the CD-Rom for sharing electronic atlas data (Keller, 1995; Morrison, 1995; Ormeling, 1995; Rystedt, 1995). Third, several of the authors discussed the potential of electronic atlases to serve different user groups e.g. students, professionals, novices, experts (Dymon, 1995; Keller, 1995; Ormeling, 1995; Rystedt, 1995). User type remains a significant concern when creating a digital atlas. Fourth, the need to make electronic atlases interactive was viewed as critical to meeting the needs and expectations of users (Keller, 1995; Ormeling, 1995; Rystedt, 1995; Smith and Parker, 1995). While the conceptions of "interactivity" have evolved since 1995, this issue remains central to electronic atlas design. Finally, several of the papers dealt with the presentation and navigation of geographic data in an electronic atlas. Ormeling (1995) in particular presented many of the challenges facing the cartographer when creating a digital atlas.

The purpose of this paper is to examine the existing guidelines for printed atlases, digital maps and the Internet with the goal of extracting those design recommendations that can be applied to digital atlases. More specifically, in this paper we will address those design issues that are particular to digital atlases on the Internet. Some of the guidelines may be applied to digital atlases published with other medium, such as CD or DVD. Also, some of the guidelines may be generalized to apply to digital cartography, in general. However, the primary focus of this paper is to present and discuss design guidelines for WWW-published digital atlases. This paper will therefore discuss design issues as they relate to printed atlases, digital maps, Internet published maps, World Wide Web (WWW) published digital atlases, and finally design guidelines for WWW Published Digital Atlases.

In a relatively new and rapidly changing field, such as computer mapping, it is common that many different terminologies evolve. For this

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discussion, we will use the term "digital" atlas to mean the many presentation types associated with the production of atlases in a computer environment (e.g., multimedia, interactive, dynamic, animated and electronic) and adequately distinguishes them from those associated with static printed atlases.

Design Issues for Printed Atlas

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Atlases are not new to the world of cartography. While there are many new challenges to presenting an atlas in a digital form, much can be directly adopted from the design of effective printed atlases. Two existing studies on the design of printed atlases are particularly informative. Hocking and Keller (1992; 1993) examined atlas design issues through the use of a survey of atlas users, and through a content analysis of atlas reviews written by professional cartographers. The results of the user survey showed that atlas users were concerned with both the content and design of the atlas. In the area of content, users were concerned that data be current and that appropriate metadata such as date, source, scale be present. While the vast majority of the users found the addition of ancillary figures such as photos, text and diagrams useful, there was a concern that the maps not be cluttered or overwhelmed by non-map material. Users also strongly urged for the inclusion of an index of maps that goes beyond the gazetteer. Each of these concerns can and should be addressed in the creation of a digital atlas. With respect to the design of the atlas, users were concerned that the maps remain simple, and not be crowded. Given potential limitations of screen resolution, this concern may be even more critical for digital maps. Two potentially related issues involve the desire of atlas users for maps of various scales for a given geographic area, and their dissatisfaction with maps that span more than one page. The digital atlas provides an ideal means of giving atlas users access to multiple scaled maps, but the inconsistencies of monitor resolutions from one user to another may make the issue of fitting an entire map on a single screen a greater challenge. Finally, the users had several concerns relating to color. They praised the use of color-coding that helped to visually organize sections of the atlas together, but they were critical of maps with too many colors, or colors that differed only slightly. Again, given the capabilities of computer monitors and video drivers, the issue of color differentiation may be even more significant for digital atlases.

The content analysis of atlas reviews written by professional cartographers had some minor differences in responses, but shared concerns with the 'non-experts'. "Consensus is that simplicity and clarity of communication is desirable. Agreement exists that scales must be rounded and clearly stated. Bold colors tend to be frowned upon, although subdued colors must be clearly separated" (Hocking and Keller, 1993:79).

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Design Issues for Digital Maps

Static, printed maps may no longer be the mostly widely produced maps with map engines such as Map Quest or Yahoo Maps, but printed paper maps still outnumber digital atlases. Printed maps allow the reader to physically interact with the map in a manner not currently possible with a digital or virtual map. The map user can touch, fold, flip, draw on, and put the printed map in their pocket. The printed map, however, lacks the potential for the multimodal interaction provided by digital maps. We hesitate to call the digital map interaction deeper, more significant, more profound, or better as the interaction may actually be less personal. But, as

Peterson (1999) states, "it is difficult to overstate the importance of this new medium for cartography (31)." The digital map offers a level of interaction that currently is not possible with a printed map, possibly providing an advantage over traditional printed maps with regard to spatial learning.

The digital map offers a map communication medium that may provide advantages over traditional printed maps. In fact, Peterson (1999) offers several advantages of interactive multimedia over printed maps. One advantage is that multiple media (text, graphics, video, sound, etc.) presented together "will lead to more realistic representations of the world (page 32)." Another advantage is that people enjoy viewing maps as part of multimedia presentations, and therefore may learn more when they are having fun. Research has shown that subjects who have viewed digital maps as well as static map presentations learn more from, and enjoy the presentation of, the dynamic over the static representations (Lobben, 1996; Freundschuh, 1999; Feeney, 2000). A third advantage arises because many people do not know how to adequately read a map—multiple sources of information provided by digital maps may help people gain more understanding of maps. A last advantage is that the exploration of multimedia as an alternative production method for spatial information furthers the theoretical development within cartography.

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While cartographic communication may be improved through the use of dynamic multimedia maps (Buziek, 1999), the advent of an alternative production method requires that cartographers explore and identify design guidelines that will help develop digital maps that function as efficient and effective spatial data display and exploration products. Cartographic researchers continue to investigate digital map design issues and several guidelines have already been addressed. While many of the guidelines follow those that have been developed for static, printed maps, the design process associated with digital maps is complicated by the fact that more media as well as potentially more dimensions of data are incorporated into the map display (Miller, 1999). But, guidelines have been suggested and some are included below.

Aesthetics

Monmonier (1991), Robinson *et. al.* (1995), Gartner (1998), and Dent (1999) have addressed the issue of map aesthetics. The overall appearance of a map, including a digital map, is profoundly important in how the map's message is perceived by the reader. In a study performed by Harrower *et. al.* (1997), they found that subjects who identified digital maps that were "the most accurate, ethical and convincing were also the maps that looked the most professional by [the researchers'] standards (33)." As the aesthetics are important for a printed map, it stands to reason that they would be important for a digital map or atlas as well. However, aesthetics is to some degree a matter of personal taste and preference. Developing an eye for cartographic aesthetics is one of the hardest traits to teach (Dent, 1999). Criteria that determines how pleasing a map appears to a reader might include color, line weight, font choices, and simplicity. Though, how should the cartographer control for these choices given the differences and lack of viewing quality control (monitor quality)? Because the specific qualities of each display device are not known to the cartographer, designing for the unknown may be accomplished (or at least simplified) by employing a design that meets minimum display standards. Some of these standards are addressed individually below.

"Developing an eye for cartographic aesthetics is one of the hardest traits to teach."

Text

Most anyone who has ever had to include text on a map (or has taught students how to effectively employ text on a map) knows that dealing with text is a complicated task. Given this, how does the cartographer approach text use on a digital map that has lower resolution relative to the printed map? Harrower *et. al.* (1997) found that illegibility of text on internet maps produced complaints from subjects.

The most legible fonts may be Times, Arial, and Helvetica as these fonts are installed on most computers, lessening the possibility that the fonts will be remapped on the host monitor (Springer, 1999). In addition, these fonts have the advantage of being more legible than other more ornate or complicated fonts, even on the printed map (Dent, 1999).

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Color

Digital map design is hindered by fewer color options than available for printed maps, as modern monitors are less capable than modern printers at creating color depth and variety (Springer, 1999). Also, different monitors may display the same RGB combinations, which may appear slightly (and sometimes drastically) different. Recently, however, the difficult process associated with selecting color for monitor display has been eased. ColorBrewer (http://www.personal.psu.edu/faculty/c/a/cab38/ColorBrewerBeta.html), an online color selection aid for cartography, allows the user to identify color combinations appropriate for a variety of intended audiences and applications including monitor display.

Map Interface

A critical issue in assessing the communicative value of the maps is the interface to the map, which "becomes a significant factor in the use of the map or map sequences" (Torguson, 1997:29). The interface must provide a means of integrating all of the media to provide effective user interaction with the digital map; such effective interaction could include basic functioning of the map presentation as well as map data analysis and manipulation (Miller, 1999). Most maps (both printed and digital) are designed to present spatial data, and care is given to create a design that allows the most direct and effective display of the spatial data. Of course, criteria that define the term *effective* will likely vary from map to map, depending on the map purpose. One goal that may be commonly held in most maps is to direct viewer attention to the data and their symbols on the map, itself. Therefore, the digital map design should, ideally, focus viewer attention on the map and not distract reader's attention to the interface system. As a result, digital map design may benefit by maintaining a structured and consistent interface.

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The interface may provide several functions, for example basic interface navigation, direct map access, and peripheral map-related interaction. Many digital maps include *next*, *back*, *home* as well as other basic functions designed to provide navigation within frames, and between sections of the map. Buttons that are common in all frames and screens, or are part of the digital map, can aid communication by maintaining the same pixel location from screen to screen. In cases where a map graphic may overlap the standard buttons, consistency may dictate that the graphic be edited, rather than the navigation buttons. In addition to the standard navigation interface, interactivity may include direct map access. This direct map

access can be provided via buttons that are an integral part of the map. For example, both thematic and reference map symbols can be programmed to provide the viewer information about the symbols meaning when selected. This level of interactivity provides the viewer with more detailed information about the elements contained on the map.

The interface may also include interactivity that is not direct, but instead provides peripheral map-related interaction. This type of interaction could include buttons that are programmed to allow the viewer to gain additional information about the map display without clicking directly on the map. This interactivity may not necessarily be designed to further explain characteristics of the map elements, but instead allow the viewer to explore additional possibilities. For example the map user might choose to re-map a choropleth map using a different classification method, or view only certain symbols, or even change the number of classes.

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Legend Design

The digital atlas can utilize both static legends and interactive legends. The static legends will differ little form those associated with printed atlases. If adopting an interactive legend, they may be presented in at least two distinct ways. First, the map may have imbedded self-describing symbols, which when accessed by the map viewer through some sort of interaction such as a roll-over or click provide its own decoding (Miller, 1999). Second, a traditional legend as seen on most printed maps may be displayed. This legend may be static or interactive, which may provide additional information about each symbol when accessed. The legend may also be structured according to hierarchy. For example, upon first observation a legend providing information about a topological map could include only the most general classes of symbols like roads, buildings and soils. However, the viewer could then click on roads revealing a subset of symbols, for instance US highways, state highways, 4-lane, 2-lane, and unpaved.

Intellectual Hierarchy, Visual Hierarchy, and Figure/Ground

The symbols on the static map that are assigned a higher level of informational content should be designed so that they maintain proper visual hierarchy (Dent, 1996). Consequently, higher-order digital map symbols should also be designed to provide maximum visibility (Miller, 1999). The author of the digital map can utilize design techniques that are not available in print-map design. Techniques such as a roll-overs, or animated symbols like blinking, color ramping, and shape changes may provide a visual hierarchy of elements in the digital map.

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Graphic Integrity

The problem of screen versus printed page resolution has been well documented and discussed by researchers. While "the visual limitations of the computer monitor [may be] immediately apparent when compared with a finely printed image (Springer, 1999:60), solving the resolution problem requires that the cartographer implement design guidelines for the digital map that may be distinctly different than those adopted for the printed map.

Scanned Images

There are general resolution differences between monitors (lower resolution) and the printed page (higher resolution) that render viewing a digital map, that was created from scanning a printed map, on a computer screen less effective. However, these types of scanned images are commonly found on the Internet. Harrower *et. al.* (1997) observed that digital maps that are scanned from printed maps may have font legibility problems; in particular, they noted that serif and italicized fonts often become illegible due to the scanning process. If possible, cartographers might avoid including scanned printed maps in their digital maps. When the mapping purpose requires that a basic thematic or reference map be included, a new and original map should be designed for the digital display, allowing the cartographer to observe and apply some of the guidelines for designing virtual digital maps. However, new designs may not always be possible.

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Consider the case of including historical, hand-drawn, paintings, or other original maps created on printed medium; clearly, these maps need be scanned to include in the digital map presentation. In this case, the cartographer needs make one of two design decisions: reduce the size of the map to screen size, or include a large image that requires scrolling to view the entire map. The detail of the original image may help select the method. A scanned map with little detail may be viewed on a single screen without losing any of the graphic integrity of the original map. However, with an original map that contains a great deal of detail, acknowledging that this is a subjective decision, the cartographer may decide to include the image as a scrolling map. With this choice, disadvantages are faced. Harrower *et. al.* (1997) suggest that maps that do not entirely display on the monitor, but instead require scrolling to see the entirety of the map are "difficulty to read, frustrating and confusing" (36).

"Because the cartographer can provide the viewer the option of zooming into the map for a more detailed view, they need not include all map elements when the map is viewed at the smallest scale."

Graphic Simplicity

The limitations imposed by a computer screen display environment will influence the information structure in a multimedia environment and may require that manageable chunks of information are used (Miller, 1999). Digital maps may be more effective if the design is less complex graphically than printed maps (Buziek, 1999; Springer, 1999). Instead of replicating a complex map, a street map or a topographic map, for example, the cartographer could use layers of data. These data layers may be accessible by creating interactivity that allows the map viewer to retrieve the needed information. Also, because the cartographer can provide the viewer the option of zooming into the map for a more detailed view, they need not include all map elements when the map is viewed at the smallest scale.

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Content Structure

Ideally, digital map products will provide an overview of the structure and/or content of the map (Miller, 1999). As mentioned above, systematic placement of navigation buttons will aid the map-reader in the exploration of the digital map. But, more than ease of navigation, the viewer may benefit from a general overview in the beginning or introductory page of the map. Following an overview, a general table of contents, which may function as a home page, could provide a grounded organization that the viewer can access from anywhere in the digital map. This access would be via a consistently positioned "Home" button, or similar.

Internet Publishing Issues

Accessibility to the Internet is on the rise (Peterson, 1999) and has become a "major medium for the dissemination of maps and it has a great potential for further growth" (van Elzakker, 2000:34). Publishing on the WWW offers cartographers some spectacular advantages not enjoyed by publishing in permanent tangible medium. Reasons for the popularity abound, but Peterson (1997) succinctly captured the essence of the reasons when he stated that "the internet presents cartographers with a faster method of map distribution, different forms of mapping, and new areas of research." (3). Specifically, internet publishing usually means lower distribution costs, less time spent in the publishing process as it is faster to publish on the internet than on paper or to CD-ROM, and less time spent on distribution and faster up-dates of edited maps.

"Viewers may become frustrated with large, slow loading files."

With these advantages, though, one important issue should be considered in the design process. File Size affects the load time of any digital map viewed over the internet and therefore may inversely affect viewer interactivity (Crampton, 1999). Viewers may become frustrated with large, slow loading files. In addition, delayed load time may impede the entire design purpose as "a slow unresponsive dynamic map interferes with the exploration of the data being presented." (Springer, 1999: 60) Cartographers, therefore, may need to take care of the final file size of the digital map that is published on the Internet.

Aside from file size as a design issue for Internet maps, few design guidelines exist for web-map designers. The lack of guidelines may be due to cartographers knowing little about how people use Web maps (van Elzakker, 2000) as relatively little attention has been paid to WWW and mapping (Crampton, 1999). Additional research on user needs and use of Web maps is needed.

WWW Published Digital Atlases: Examples

As we have seen the WWW continues to grow as a popular dissemination method for maps. Thousands of sites contain maps of many forms, for instance static, multimedia, interactive, and animated maps. Interactive atlases are no exception and many are found on the WWW, as well as on CD-ROM.

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The IMAA (Interactive Multimedia Atlas of Austria) allows users to explore the topographic and socio-economic attributes of Austria through maps, text, photography, and videos (Kelnhofer, Pammer and Schimon, 1999). The planned new edition of the Atlas of Switzerland, which includes both printed as well as multimedia components that may be used in conjunction with each other illustrates the following themes: international relations, natural space and environment, population and society, economy, infrastructure and traffic, and culture and politics (Hurni, Bär, and Sieber, 1999).

The Atlas du Quebec et de ses regions is under production with sections available on the Web at http://www.unites.uqam.ca/atlasQuebec/. The atlas allows the viewer to explore socio-economic data of the Province at three different map scales (Carriere, 1999).

The new Atlas of Florida on CD-Rom represents a project that has been 20 years in development. The digital atlas was created based on previous printed versions of the Atlas, and maintains many of the sections contained in the printed form including topography, geology, geophysics, hydrology, weather and climate, soils, ecosystems, wildlife habitats, Indians, Spanish exploration, the Civil War, cultural landscapes, architec-

ture, the arts, population, economy, and recreation and tourism. The digital version of the atlas was enhanced with more maps, data, and photographs (Anderson, 1999).

Like the Atlas of Switzerland, the Atlas of the Federal Republic of Germany also includes both printed and digital editions that contain dozens of topics intended for a wide audience, from government agencies to the general public (Lambrecht, 1999).

Design Guidelines for WWW Published Digital Atlases

"One of the greatest challenges of creating a digital atlas concerns the overall organization of the atlas components."

In short, an online atlas should contain many of the same features found in a printed atlas (Richard, 1999) but should be designed according to many of the guidelines adopted for digital maps. When designing the digital atlas, the cartographer will apply many of the guidelines for printed atlas production and digital map production as discussed above. However, the design of an effective digital atlas must consider more than those issues associated with the printed atlas and the digital map. The digital atlas has unique design challenges, some of which are addressed below.

Organization

One of the greatest challenges of creating a digital atlas concerns the overall organization of the atlas components. In the printed form, the organization of the atlas is much more apparent to the user. With the digital atlas, the organization is hidden and must be explicitly communicated to the user. As a result, the scope of the interactivity content and navigation should be presented as clearly and simply as possible.

Navigation

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Given the random manner in which people explore digital atlases, and because the organizational structure of the atlas is hidden, it is necessary to provide the user with some means to aid in his/her navigation of the atlas. For an atlas it is important to provide the user an effective means to explore the various sections. Therefore an important component of the digital atlas is a table of contents that is available at all times. Whether the atlas provides a clickable table of contents on every page or a permanent link to the table is an individual design choice. In either case, it is important to provide the atlas user a means to manage "where" they are in the atlas. Based on the guidelines for static printed atlases, it is also recommended that a digital atlas provide the user with a gazetteer and an index to the individual maps. The gazetteer and the index can both be presented as hypertext pages and accessed through links in the table of contents.

Minimizing Text

As the printed atlas differs in design and content from a single map (or even a map series) so does the digital atlas differ from the digital map. The atlas provides a collection of maps that share a common theme, and while the maps are still a primary focus in the digital atlas, supporting media also provide a significant amount of information. Effort should be made to transform information into graphic representations (Buziek 1999), but when that conversion is not possible, the cartographer is presented with other options. Auditory narration may be employed in place of paragraphs of text. In addition, a clickable textual graph may be created to

allow the map-reader to explore the narrative in his or her own order or format. Finally, sometimes a description of a sound or atmosphere can be replaced by a recording of the actual sound.

Real-Time Data Updating

In most cases, publishing an atlas on the Internet offers many of the advantages offered above, such as real-time data access, frequent updates, broad dissemination. Also, a creative and adept cartographer can add an additional atlas feature that is currently unavailable through traditional printed atlas. Webcams provide streams of image files that can be updated at variable rates of speed. Monmonier (2000) suggests that webcams can function as a mode of "cartographic surveillance" and can provide "qualitative or quantitative information about places" (53). Imagine, for example, an atlas of South America, which devotes a section to Amazonian wildlife. Traditionally, printed atlas maps would likely be enhanced with photographs of flora and fauna. Strategically placed webcams could capture real Amazon scenes, allowing the viewer to glimpse streaming video of life in the Amazon. While actual learning benefits may not be known, webcams at least arguably offer a method of presenting information that is currently not duplicated.

"Traditionally, printed atlas maps would likely be enhanced with photographs of flora and fauna. Strategically placed webcams could capture real Amazon scenes . . ."

Data Accessibility

In the simplest case, the printed atlas may be converted and presented in digital form. An interactive table of contents, structured navigation, clickable thematic and reference maps, interactive legends, photographs, graphs, and any other element included in the printed atlas can be included in the digital atlas. In creating this form of atlas, the design may benefit from applying the guidelines associated with digital maps as well as the organization guidelines presented above.

However, the ability to query information or obtain the relevant data is important in the design single digital maps (Johnson and Gluck, 1997), and the digital atlas as well. The cartographer may choose to include a truly interactive database, allowing the user to carry out remedial GIS querying, or simply include a clickable table of contents.

The digital atlas need not be constrained to a series of interactive but pre-programmed animated or static maps—referred to as a closed multimedia atlas where every possibly interactivity is programmed by the author (Borchert, 1999). In other words, the cartographer need not explicitly plan the specific interactivity, and the specific use need not be restricted for the atlas user. In addition to, or instead of creating planned thematic maps, the digital atlas may contain a GIS format of viewing thematic maps. Through this format, atlas users may access the atlas' spatial data sets with which they can perform more personalized functions. Consider again the atlas of South America. Atlas users may choose to create choropleth maps visualizing Amazonian flora or fauna, choosing their classes and their specific themes. In addition, simple GIS functions such as queries and buffering may be accomplished (Gartner, 1999; Swanson 1999; Zaslavsky, 2000; Open GIS Consortium, www.opengis.org).

"The digital atlas need not be constrained to a series of interactive but pre-programmed animated or static maps . . ."

CONCLUSION

While cartographers benefit from a rich array of sources that provide guidelines for designing static maps, guidelines for digital atlas design are few. Defining or even identifying a digital atlas may be difficult as many presentations on the WWW self-identified as Web atlases consist of only a

few html pages with a few maps (Richard, 1999). Do these presentations constitute an atlas? What are the content (qualitative) and the number (quantitative) requirements in order to consider a presentation a digital atlas?

"Design guidelines will evolve as methods for dissemination can display larger images, more detail, higher resolution, and novel media."

The guidelines presented in this paper may not exhaust all of the design concerns that a cartographer might encounter when creating a digital atlas. However, the guidelines presented in this paper may help advance the discussion of designing digital atlases, while keeping in mind that digital map and atlas design guidelines should be dynamic. Design guidelines will evolve as methods for dissemination can display larger images, more detail, higher resolution, and novel media.

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