Distributed Cartography: A Look at Web-Mapping Service and How it Changes the Mapping Process.

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Abstract

Using the Internet as a distribution method for cartographic products has led to a whole host of new challenges for cartographers and map users. Most of the maps distributed on the Internet have come from sole source cartographic providers. With the development and implementation of web-mapping services, multiple data providers are synchronized into a single information stream for building and delivering cartographic products on the Internet. This research examines this technological change and how cartographers must adapt their mapping process to use a web-mapping service as a tool for spatial communication.

Mapping services can be grouped into two groups: private and public. The private mapping service is one that is held within a set of known users who understand and follow in-house policies and procedures. An example of this would be several departments within a government agency sharing their database among themselves to eliminated redundant data management tasks. This type of private mapping services is disturbed through a Local Area Network (LAN). The public mapping service is one that is developed by a group with a set of user access policies. The external users access may be different than that of local users. In many cases, the external users may now input into the access policies and data structure. This type of mapping service can produce both graphic and data cartographic products.

One of the major issues for cartographers to consider when adapting web-mapping services into their mapping process is understanding their own process. Cartography is a creative process with a loose set of rules that define it. Most of the conceptualizations of the process shows it as a linear process related to map communication. It has become more evident that the mapping process is a self-adjusting network. By using a self-adjusting network metaphor for the mapping process, web-mapping services can be implemented more easily into the mapping process.

Introduction

The Internet has been the greatest medium development for cartographers since the advent of paper. Placing maps on the Internet eliminates many of the classic cartographic problems: timeliness, customization, query, distribution, and user interaction. Web based cartographers can gather new information, update, map, and distribute the information in near-real time. This research looks at three concepts; web mapping services, cartographic process, and connectionist psychology to form a possible framework for future intelligent Internet mapping.

This research will focuses on how to link the three concepts together. Before detailing the linkages, one must first discuss the concepts independently before moving forward. Once a general description of the concepts is complete, the next step is to develop the links between the concepts. In this section the linkage will be discussed conceptually with limited discussion of the technical possibilities. In the final section of the paper, a discussion of the possible future of Internet mapping well be explored.

Web Mapping Service

Web mapping service is the newest of the three concepts being discussed in this paper. Web mapping service is associated with any number of definitions. One can say that a company that publishes maps on the Internet is a web mapping services similar to a printer or service bureau. In this paper the term web mapping services is defined as one or more web map servers or web feature services that distribute map data to Internet clients. This definition is similar to the Open Geospatial Consortium WMS definition. The one difference between the two is the inclusion of the OpenGIS specification standard (Open Geospatial Consortium, 2004) in the Open Geospatial Consortium WMS definition. In this paper the more conceptual definition will be used to relate WMS to the cartographic process and connectionist psychology. To further explain this definition, the concepts of a web map server and web feature server will need to be explained.

The web map and web feature servers both develop and distribute map data to geospatial data portals. The geospatial data portal then combines cartographic data and sends it to the Internet client. The web map server creates image graphics that can be overlaid with other geographic data. A web feature server will distribute feature data, i.e. vector data to geospatial data portals when requested. One can see the OpenGIS standards definition for both of these server types and others at the Open Geospatial Consortium (2004).

The web map and feature server types fall under the umbrella term web service. A web service is a functionality that is exposed to the Web and has a standard interaction format (Zaslavsky, 2003). The key to the implementation of web service is the platform independent standard that it is built on. Zaslavsky (2003) traces the standards history for present day Simple Object Access Protocol (SOAP), Web Services Definition Language (WSDL) and Universal Description Discovery and Integration (UDDI) to its predecessors Common Object Request Broker Architecture (CORBA) or Distributed Component Object Model (DCOM). Recently mapping servers have been developed using the SOAP/WSDL/UDDI standards. Microsoft's MapPoint .NET and ESRI's ArcWeb were developed with these standards (Zaslavsky, 2003).

Concept Model for Web Mapping Service

In the previous section, a conceptual definition of a web mapping service was compared to the Open Geospatial Science Consortium (2004) definition. This section will focus on the conceptual understanding of WMS in the context of data exchange across the Internet. Figure 1 illustrates how both public and private web mapping services are developed. DiBiase (1990) and MacEachren (1994) both created models of communication and visualization that included the concept of public and private communication. In both of these models the concept of private centers on an individual. In this research the term private applies to an organizational group. A National Mapping Organization (NMO) will develop a web mapping service for its internal use. The public WMS (Figure 1a) is different than a private WMS (Figure 1b). The difference between the public and private WMS is that data can be brought into the private mapping service but data does not goes out of the organization. The analogy of a black hole comes to mind where light, i.e. data, is pulled into the mapping service but it can get out. The reason that this distinction is important relates to associated knowledge lost to the public realm.

Any knowledge gained by the linkages of web mapping and feature servers is only available to the intranet client. By looking at knowledge from a society point of view, having organizations hold knowledge on their intranet provides little assistance to create a better universal knowledge.

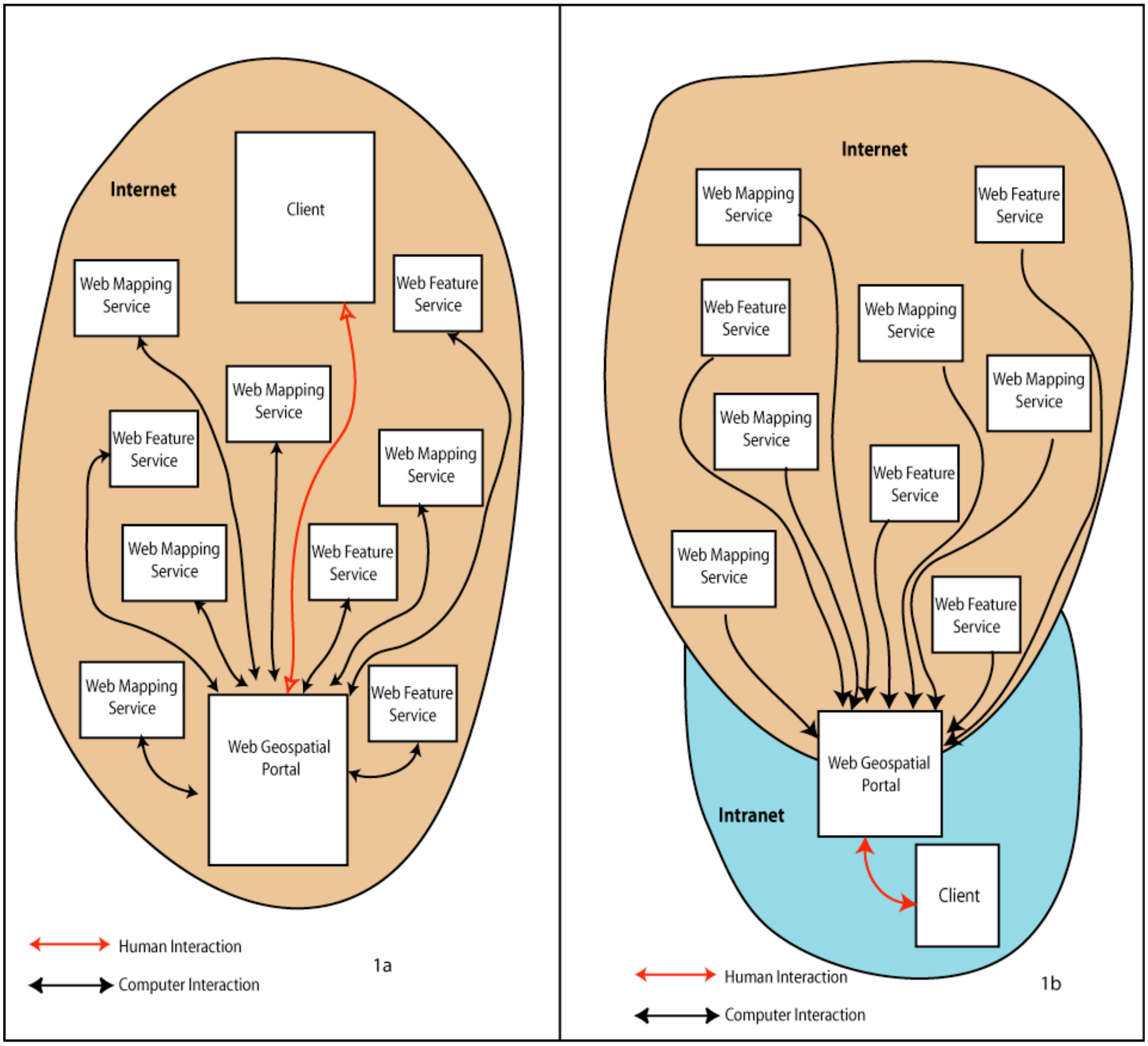

Figure 1 Framework for Public and Private Web Mapping Servers. Figure 1a illustrates that client and web geospatial portals are located in the public internet space. Part b shows that all of the human interaction is located in a private (intranet) space and the associative knowledge is hidden from the public space.

Cartographic Processes

The idea of a cartographic process has been around for hundreds of years. Many cartographers have written about it. In general, cartographers see the cartographic process as being either the mechanical process or the conceptual process. In Bies and Long's (1983) book the idea of cartographic process is the mechanical process of topographic drafting. Monkhouse and Wilkinson (1963) systematically describe how to gather and represent all kinds of data in map and diagram form. About this time a more conceptual treatment of cartographic processes began to arise. Raisz (1962) wrote a book that included a short section of the principles of map making. In this section he identifies several conceptual ideas within the cartographic process. His points were scale, selection, emphasize, symbolize, generalization, typography, and spatial referencing. Some of the points are conceptual points like selection emphasize, and generalization, while others, i.e. spatial referencing and typography are more mechanical in nature. Previous to Raisz's book, Robinson (1953) published a book that outlined the cartographic design process. Robinson developed the "cartographic abstraction" model which is still a mainstay of chapter one in most cartography textbooks since its original publication.

The next major development in the cartographic process is a basic consideration for the map reader. This development was fueled by the infusion of ideas centered on the classical communication model. The change in perspective, from maps as a product to be produced to a conduit for communication, has led to many different versions of the map communication model. Dent (1999, p 14) produced a model of map communication that had changed significantly from the model in his second edition book (Dent 1985, p 16). Within this and other contemporary models of the cartography process, mechanical, cartographic abstraction and map communication concepts were combined. Starting in the early 1990's with DiBiase's (1990) visual thinking and communication model followed by MacEachren's (1994) visualization cube the model of the cartographic process was again altered to include additional ideas.   With the latest changes being the addition of the concepts of visualization, it appears the model for the cartographic process is more of a comprehensive list of specific cartographic activities. MacEachren's model focuses primarily on a framework that will include all map readers while paying little attention to the mechanical and cartographic abstraction components of cartography. It should be noted that MacEachren's model is not a straightforward model of the cartographic process but a model of visualization. This distinction is important and stands as an important advancement in the theory of graphical communication. The concept within the model helps cartographers in numerous applications of representation and integrating new technologies. Yet it makes the model of the cartographic process model more focused on one small part of the whole process.

Slocum (2003, p 5 or p 219) provides a model of map communication. In the Slocum model, the mechanical concepts have been completely removed. In an age where computers, software, sensors, and network communication standards are created and disappear in the wink of an eye, including mechanical components makes little sense for a conceptual model. Slocum does not directly illustrate cartographic abstraction within the model, but it is implied. This model is closer to the classic communication model than any other discussed. It is linear with five steps and a short feedback loop.

With all these different models, developing a comprehensive cartographic process model is difficult. Figure 2 shows the conceptual model for the cartographic process used in this paper. This model attempts to use the best of the concepts discussed in this research. As in Slocum's (2003) model, the mechanical aspects of cartography are changing so fast that a model including them will be obsolete in just a few years. The cartographic process model is linear with four steps. This model does have a feedback loop in it. This is a significant departure from the map communication models described. It is clear that feedback is a fundamental part of communication and within the cartographic process is a principle goal. For this model, leaving out this feedback loop was more of a reflection that feedback is implicitly understood for map designing. The concept of cartographic abstraction is central to this model. For abstraction to work one must consider the geographic environment being mapped. The conversion of the real world into a graphic representation is a complex process that is driven by a central need or question. Again the goal is to develop a simple conceptual model of the cartographic process to be integrated with Web mapping services and connectionist psychology.

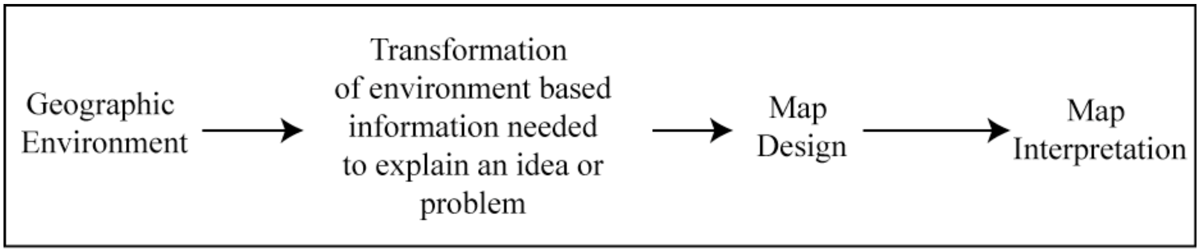

Figure 2. Conceptual Model of the Cartographic Process. This model is a composite model of the cartographic processes from many cartographic writers. The model tries to highlight the core elements between all the models.

Connectionist Model

The connectionist model is the third concept being discussed in this research. Ellis and Humphreys (1999, p 13) start their definition of connectionism by paraphrasing a famous quote from Wittgenstein "that an attempt to provide a definitive list of the attributes of some categories is misguided." Ellis and Humphreys' (1999) explain that there are numerous models that are similar to one another that make up connectionist computing. It is these similarities that define connectionist theory. In the end, seven similarities are defined by Ellis and Humphreys (1999) that define connectionist theory.

1. "Connectionism is an attempt to explore the computational properties of brain like mechanisms…
2. Connectionist schemes are well suited to the solution of problems that involve multiple simultaneous constraint satisfaction…
3. Connectionism has a theory of learning…
4. The organization of memory in connectionist networks is highly distinctive…
5. Units in connectionist networks can represent or stand for things in the world…
6. Rule-following behavior may be realized in connectionist networks without any need to have the rules represented explicitly in the network…
7. The performance of connectionist models breaks down gracefully rather than in an all-or-none fashion, when the models are damaged…"

Currently one of the confusing aspects of with connectionist theory is that it used in many fields. Computer scientists work with a neural network model. The new field of cognitive neuroscience uses connectionist theory as both a foundation and research paradigm. The discipline of psychology has connectionism as an alternative model for psychological explanation (MacDonald, 1995). In this research, the aspect of connectionist theory that is relevant is the simple computational model of neurons and learning theory. Figure 3a shows the simple computational model of neurons. Two neurons are connected by synapses. The neurons can send either excitatory or inhibitory stimuli to another neuron. A third state, neutral connection can also occur. The neurons themselves also have inhibited, excited or neutral states depending on the influences from their connected neurons. This basic model comes from McCulloch and Pitts (1943). McCulloch and Pitts' (1943) model is slightly different in the context that they didn't use a side bar graphic metaphor. Instead their model had multiple connections for inhibitive and excited properties (Ellis and Humphreys, 1999).

Once you have a simple neuron to neuron connection (synapse), a network can be established for learning and storing information. In the connectionist modeling approach nodes in the network are given a known real world concept. From the cognitive neuroscience field it is understood that human concepts are actually a large set of networked neurons in the brain. In Figure 3b a simplified example of a learning network is shown. The input neurons are connected to a hidden unit that in turn is connected to an output. The connection between the input and hidden units can be one of the three states. At anytime when the sum of the input connection exceeds the hidden units' excitement threshold, the hidden unit becomes excited. The status of the hidden unit will determine its connection to the output unit. The result of this process was first developed by Hebb (1949) and is referred to as Hebbian learning in cell assemblies (Ellis and Humphreys, 1999).

The final part of connection theory that one must consider here is the development of a multi-node hidden layer network. Figure 3c illustrates this type of network. Currently there are numerous computation network models. Ellis and Humphreys (1999) classify them into nine groups.

1. Perceptron
2. Associative
3. Hopfield
4. Boltzmann
5. Back-propagation
6. Recurrent
7. Competitive
8. Radial Basis Function (RBF)
9. Adaptive Resonance Theory (ART)

An explanation for this classification method is outside the scope of this research. As in other scientific taxonomy the different classes attempt to fix the known short comes of the previous class.

Linear Processes vs. Network Processes

For cartographers many of the mapping processes have been conceptualized as a linear process. Since the development of the computer and the computer flow chart, idea after idea have been illustrated with the square, diamond and connecting line look of the computer flow chart. Two main reasons exist for using the computer flow chart method. The first is the ease of construction. Making a box and writing some text is a simple task. Numerous tools were created for this task. Today you can still find flow chart templates at most university bookstores. Along with the templates, all the early and current graphic software can construct boxes, draw text in the box, and make lines with arrows from there standard tool palette. Although the construction of a computer flow chart is very simple today, it is the second reason for using flow charts that is more important.

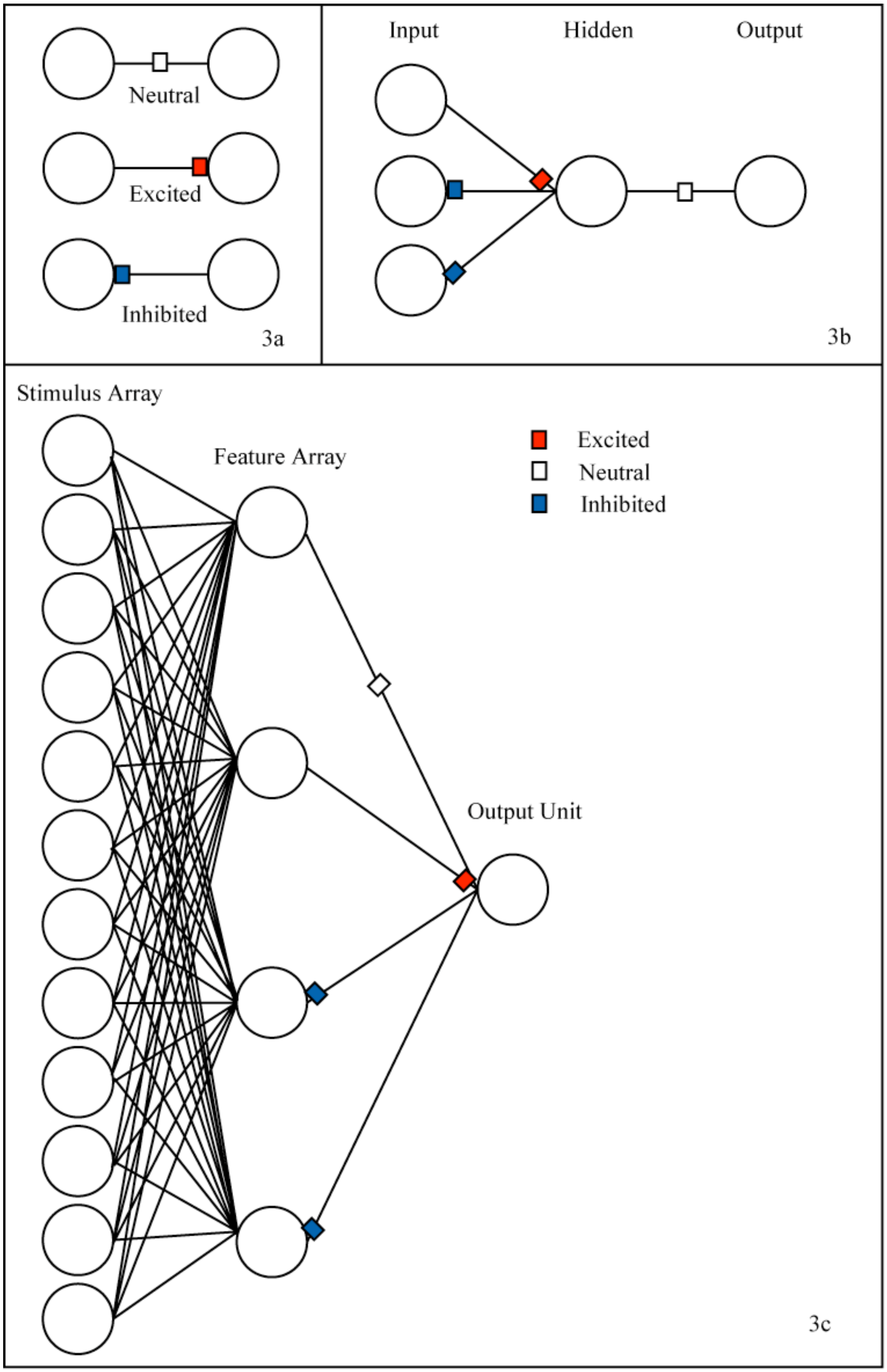

Figure 3. Strucuture of a Connectionist Psychology Model. Part 3a shows the simple relationships between two connectionist structures. In part 3b is a simple three level knowledge structure with input, hidden and output structures. The final part of the illustration, (3c) shows a large stimulus array with feature elements that are connected to a single output unit.

Flow charts are the expression of conceptual analytical thought. One could extend this logic and say since it's an analytical thought, it is a direct expression of the scientific process. For academic cartographers however, the flow chart diagram is a simplification of ideas for student learning. In this research the linear conceptual model of the cartographic process (Figure 2) is a straw man tool. For students learning about cartography, flow chart diagrams are easy to read and understand, but as they become more familiar with the subject they will question its content based any number of specific examples. Like the map, which is made at a specific scale, the question it can answer must be at the same scale of the map. Small scale maps cannot provide the answers to large scale questions.

Another reason for using the linear metaphor to express the cartographic process concept comes from the individualized approach to cartography and cartographic education. Historically cartographers worked independently and for thematic maps today they still do. Cartographic textbooks tend to be written as if the readers will make maps themselves. Academic courses are constructed for students to work independently for their course evaluation. This causes cartographers to see the process of cartography as an internal linear sequence. However, many cartographers today work in large mapping organization like a NMO or mapping company. This individual approach to cartography must give way to a team approach to cartography. The idea of a team could be viewed as a network.

Networks are powerful structure for many reasons. In the context of making paper maps the distribution of tasks across a network allows for technical specialization and expertise, which an individual would never master. The network allows for focused technical innovation within a node that will then pulse through the entire network. In the context of web mapping services when on a web mapping server, improvements in a database or service results in all the connected geospatial data portals to benefit instantly. With its inherent benefits the network model is difficult to implement because of the traditional linear approach to cartography.

Applied Connection Theory with Web Mapping Services

What this research has set out to do was to show that it is possible and logical to integrate connectionist theory, web mapping services and the cartographic process. A first look at the three concepts and shows the similarities. The cartographic process is diagrammed as a linear process, but many times within the industry it is done within a network model. Web mapping services is computer network model for exchanging geospatial data. Connectionist theory is a network model of explaining and modeling human cognition. Figure 4 shows integration of the three concepts into one conceptual model. Figure 4a shows how the model would be implemented for public web mapping services. Figure 4b shows how the model is different in the private web mapping service (DiBiase 1990, and MacEachren 1994). The geospatial data portal functions as the hidden unit of the connection model. The connection between the input fields and the hidden units are the client's request to the portal. As the portal (hidden unit) is exposed to the clients input pattern and it will adjust it connection to the web mapping and feature servers (output units). Since the connectionist model is a learning model over time as more and more clients interact with the portal, it should be able to learn the client interaction patterns and make many changes with fewer requests and get the client to its desired information faster.

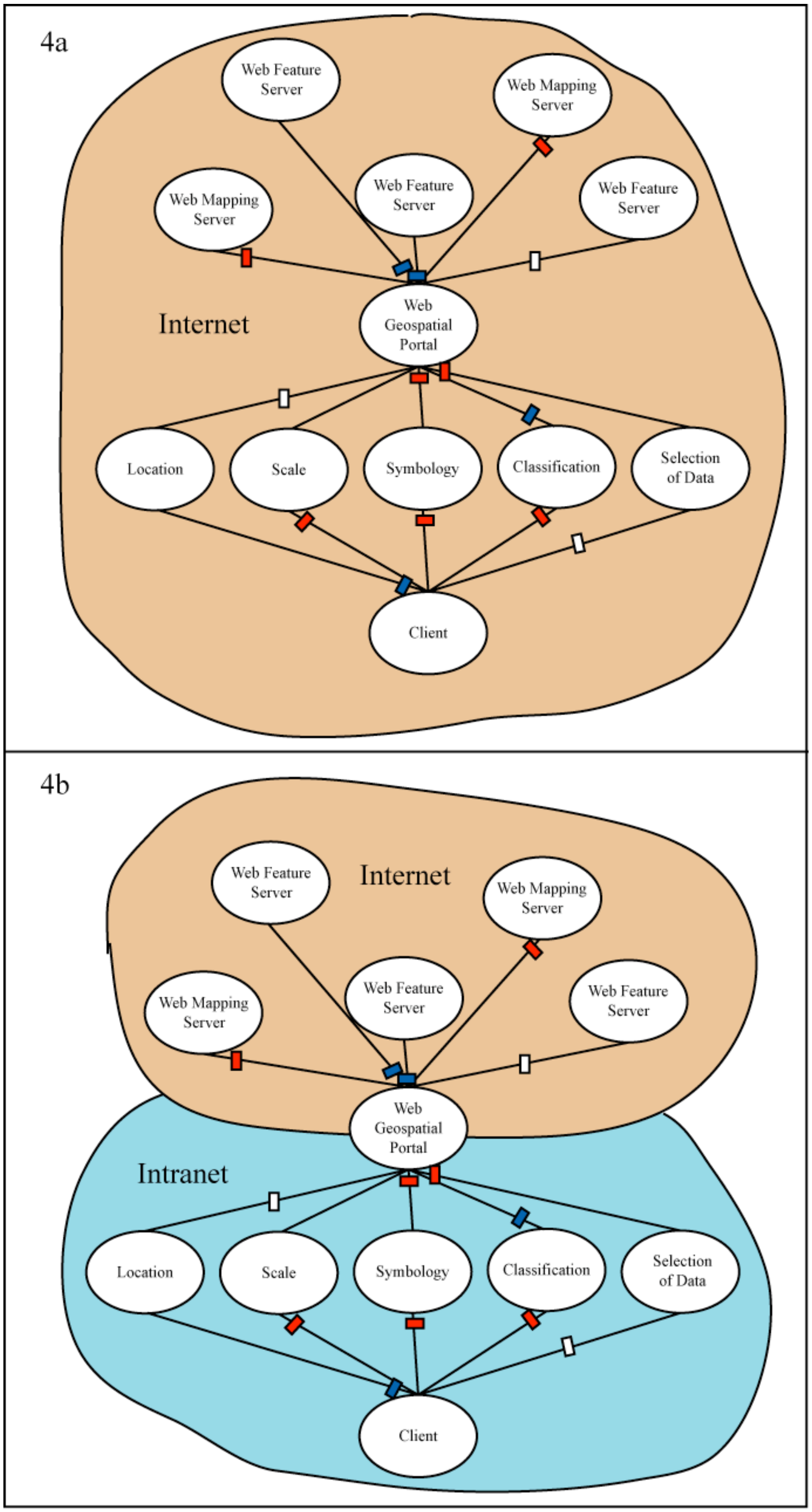

Figure 4 Integrated Model of Web Mapping Services, Cartographic Process, and Connectionist Psychology. In 4a the associative knowledge create by client is available cross the Internet. For private web mapping services the associative knowledge is separated from the internet knowledge (4b).

Implementation

How does one get this to work? The standardized interaction of WMS is already a good start. Both the web mapping and feature servers have standard request protocols. These client server transactions are sent, received, processed, and discarded very quickly while clients are using the WMS. For the WMS to integrate a connection model in order to optimize the interaction process, a series of client request parsers would be used. The request parser would be used to change the client WMS requests into input fields stimuli. For a starting point consider location, and scale. For WMS these are two principle components that are client defined. In most cases the WMS sets the selection of data, symbolization, and classification. At the onset of a users episodic action, the WMS changes location and scale factor. The scale and location parser would capture this input stimulus for the connectionist network. An episodic action is not a single action but a sequential group. If the next user interaction is again location and scale then the user is in a location search action. But if the next action alters the default WMS setting for the selection of data, symbolization or classification, the client is in a map redesign action. Once the user is at the end of the redesign action, the resulting setting for location, scale, selection of data, symbolization and classification would be passed into the connectionist model. The connectionist model needs a significant amount of training to learn, but once a pattern is learned the pattern would be used to reset the WMS setting and the connection model will continue observing the user patterns.

Conclusion

From this research several key conceptual models used in cartography have been reviewed. Through this review simplified conceptual model of the cartographic process was formed based on the aspects of the mechanical, abstraction, communication and visualization model. This simplified model (Figure 2) is not intended to replace the map communication models of Slocum (2003), or Dent (1999) or visualization models of DiBiase (1990) or MacEachren (1994). The cartographic process model is only used to construct a simple view of this process so that it can be fitted with the conceptualization of WMS, and connectionist theory.

This research also examined briefly the pervasiveness of the linear model in cartographic theories. The study shows how in reality these linear theories fall apart when evaluated in detail. Some possible explanations for the dominant use of linear model is based on cartographic education and the linear aspect of the scientific method. It is evident from large mapping organizational structures and WMS those linear models of cartographic theory are limited in their implementation.

Network models like WMS and connectionist theory fit together (Figure 4) with cartographic process model. With the different model fitted together a plausible implementation plan was reviewed. It is important to consider that by using the Internet maps and connection theory it appears an intelligent map would result for either intranet or Internet map. This paper has shown a possible path to developing an intelligent map. Like any scientific work, the results lead to more questions and research. Future research in this area should look at which connectionist learning model should be used and how to develop a parser system for Internet client episodic action events, Another question is how web mapping and feature servers standards can be updated to included this valuable associated knowledge for intelligent maps.

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