Embracing Peer-to-Peer and Small-Worlds Networks to lower barriers for participating within a Global GeoCommunity

Cristina Arciniegas

Department of Information Science, City University,
London, Northampton Square EC1V OHB
Tel +44 (0) 207 040 4044
Email *M.C.Arciniegas@city.ac.uk*,

Biography

Cristina is a research student at City University, London. She holds a MSc in Geographic Information from City University and a First Degree in Computer Science from Universidad Industrial de Santander in Bucaramanga, Colombia. Her research interests include distributed networks for geographic information exchange, web communities, Java programming and geovisualisation.

JO WOOD
Department of Information Science, City University, London, Northampton Square EC1V OHB Tel +44 (0) 207 040 0146; Fax +44 (0) 207 040 8584; Email jwo@soi.city.ac.uk

BIOGRAPHY
Jo Wood is a senior lecturer in Geographic Information at the department of Information Science at City University. He has research interests in terrain analysis and visualisation, Java programming, technologies for the distribution of GI, and e-learning.

1. Introduction

An awareness of the importance of geographic information (GI) has risen exponentially in recent years. It has generated a myriad of this special kind of information in a digital format. As a consequence, a Global GeoCommunity of GI-sharing researchers and practitioners has increased in number, generating an urgent need for a dynamic and self organizing network that allows them not just to retrieve available GI but also to provide their own input to the rest of the community.

Perhaps, this kind of network might seem like any Global, National or Regional Spatial Data Infrastructure (SDI) [1] that is already working with great success (for example, the Canadian GeoConnections [2]). However, almost all SDI depict a data-centered client-server architecture where the user (client) plays just a passive role of GI retriever, being on the servers where all heavy work is largely concentrated. Therefore, all potential users' resources like CPU and storage capacity or even GI available are grossly underused. Moreover, to become a GI provider in such a network, it is necessary as is stated in [3] to possess a high level of sophistication and

financial investment that limit the participation on any SDI to a number of government agencies and specialized private firms.

Using the client-server paradigm within SDI's domain is hampering the development of a truly dynamic GeoCommunity that encourages user's participation and the exchange of ever-available geodata [3]. Therefore, within the actual SDI's architectures, small GI producers (like independent consultants or individual users) are not able to easily share their GI or take a more active role within the GeoCommunity. The GeoCommunity should not be any longer a "clique" where just geo scientist, powerful public agencies or private companies can actively participate.

Here, we propose a solution that replaces the traditional client-server architecture for sharing GI with an architecture that exploits the peer-to-peer Network's mindset coupled with a 'small-worlds network' topology.

2. GeoCommunity, Peer-to-Peer Computing and Small- Worlds Communities.

Among potential platforms of the GeoCommunity there are a heterogeneous set of computing devices, varying from powerful mainframes or workstations to Global Position System (GPS) receivers to PDAs, ready to offer and share GI. Therefore, a requirement of a more inclusive GeoCommunity is that all kind of devices and users can communicate easily and all their resources can be organized and made available across the network. Here, is where P2P computing can make a difference.

According to [3], the core paradigm of a "true" P2P network is that all significant communications take place between cooperating peers, distributing computational workload among the peers involved. Within a P2P network there is no need of a central server as all peers are treated as equals, even though they may not share the same capabilities.

Additionally, a P2P network does not require a predefined topology (structure), as any peer can leave or join the network at any time. Hence, part of the aim of this research is to exploit this kind of dynamism in order to facilitate the participation of a range of users within the GeoCommunity without compromising GI availability. Every possible user will be represented as an active peer, moving away from being considered just a passive player within the network and giving the possibility of being producer and retriever of GI at the same time.

However, for the user behind every peer, the erratic on-off behaviour of the network makes the availability of GI resources potentially unpredictable. Hence, it is necessary and vital to try to find any recurring pattern that may help to predict the general behaviour of a GeoCommunity. It is here where a question about a potential use of Small-Worlds Networks arises.

The concept of the 'Small World' has been applied to many kind of Network based on the "six degrees of separation concept" [4]. It suggests that typically, no matter how big the network is or how many elements or nodes may it have, any anyone or anything can be reached through a short string of no more than six acquaintances. For

example, two people who do not know each other can find a friendship chain of distance of six people or less.

According to [5], social networks in which nodes are people and edges are relationships or the World Wide Web, in which nodes are pages and edges are hyperlinks, are all small-worlds networks.

Here we suggest that GeoCommunites too behave as a 'small world' in order to exploit possible patterns and design a dynamic self-organizing P2P architecture. Figure 1 depicts a group of potential users within the GeoCommunity where the heterogeneity will play a key role.

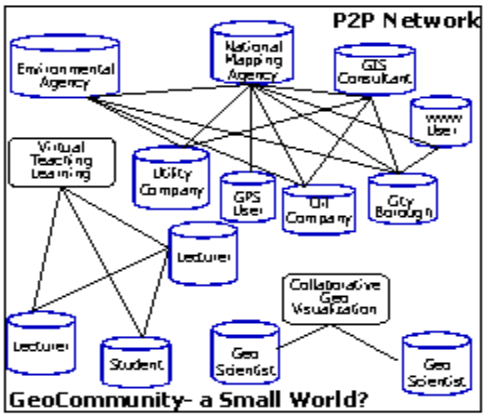

Figure No. 1 GeoCommunity

Due to the characteristics that make GI special, like topology, geometry, spatio-temporal data or data volume among many, dealing with it is a highly complex process. The GeoCommunity faces a challenge where information organization, access, display and use - with "maps" no longer is conceived of as simply graphic representation of geographic space, but as dynamic portals to interconnected, distributed geospatial data resources [7].

3. Challenges

The challenge raised involves a fusion between a data-centred approach exhibited by the SDI (ontologies, metadata, information retrieval and geovisualization of GI [6]) and a user-centred approach, where the key is to answer the question 'how can we form and exploit the small world within GeoCommunity?' that allows us to define an appropriate network architecture for effective sharing GI within the Global GeoCommunity.

4. Conclusion

This research speculates that the embracing of peer-to-peer computing and the small-world network is the way to depict a natural network's behaviours within the Global GeoCommunity, facilitating and encouraging the participation of more users and risen the availability of GI.

5. References

[1] D.D Nebert, *Developing Spatial Data Infrastructures: The SDI Cookbook*, Technical Working Group Chair GSDI, 2001.

[2] GeoConnections: Canadian's Geographic Information on the Internet, 2003 http://cgdi.gc.ca/ [viewed May 29, 2003]

[3] T. Vögele and C. Schlieder, "The Use of Spatial Metadata for Information Retrieval in Peer-to-Peer Networks", Proceedings of 5th AGILE Conference on Geographic Information Science, Palma de Mallorca, Spain, April 2002, pp. 279-289.

[4] D.J. Watts, Small *Worlds. The Dynamics of networks between Order and Randomness*, Princeton University Press, Princeton, New jersey, 1999.

[5] A. Iamnitchi, M. Ripeanu and I. Foster, "Locating Data in (Small-World) Peer-to-Peer Scientific Collaborations", 1st International Workshop on Peer-to-Peer Systems (IPTPS'02), Cambridge, MA, March 2002.

[6] H. Stuckenschmidt, U. Visser, G. Schuster and T. Vögele, " Ontologies for geographic information integration". In Proceedings of the workshop intelligent methods for handling environmental information: Special aspects of processing space and time, Magdeburg, Germany. 1999

[7] A. M. MacEachren and M. Kraak, "Research Challenges in Geovisulization", *Cartography and Geographic Information Science,* Journal of the American Congress on Surveying and Mapping, January 2001, pp 3-12.