Are Societal GIS feasible? A Web Services Solution

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ABSTRACT

Geospatial Web Services (GIS) are changing the way in which spatial data and functionality is managed, analysed and distributed. They provide opportunities that will unlock GIS functionality for a far wider audience than has hitherto been seen - creating the possibility for truly societal spatial data information networks. They also have significant benefits for data managers and developers alike, providing an environment for rapid system development and, potentially, overcoming longstanding issues of security, update and licensing. Illustrated by a series of case studies, this paper examines this rapidly evolving field, assessing current technology, opportunities and limitations.

KEYWORDS

Societal GIS, Interoperability, Web services, Open Systems, Standards

INTRODUCTION

This paper first explores the relationship between information and society before going on to examine the requirements of Societal GIS. Based on this definition it then reviews GIS Web Services to examine the extent these are capable of meeting these requirements. The discussion focuses on a number of examples drawn from around the world of Web Services that are beginning to take up the role of Societal GIS.

INFORMATION AND SOCIETY

Lying at the heart of any society is communication – the transfer or 'flow' of information. Through the flow of information understanding between different groups is gained, commonalities discovered and shared, coordinated action towards common goals defined. Equal access to information dispels rumour, suspicion and fear.

Society often goes unnoticed as individuals circulate within their own groups however they are defined - by family, profession, age, nationality, race, religion or interest. It is more often that not, major events – festive, arduous, traumatic –that highlight both a basic human need for society and the strength of the one that surrounds us. The response, for example, to 9/11 or humanitarian relief efforts in the wake of natural disasters such as landslides, earthquakes, tornados, draught and famine. Or to the Olympics or football's World Cup. The collective response to outbreaks of pandemic disease – Bovine Spongiform Encephalopathy (BSE) or Severe Acute Respiratory Syndrome (SARS).

Such events 'bring people together' – they create a shared experience that provides contact between normally separate groups and aids the flow of ideas and information between them. In the case of emergency or humanitarian relief operations, the ability of society to effectively respond to a particular situation, is directly dependent on the transfer of information through it. It is only through the pooling and sharing of resources can communities effectively respond to what are often unexpected and seemingly insurmountable challenges.

This applies equally at the local neighbourhood level as it does at the global.

SOCIETAL GIS

A Societal GIS is defined as an "infrastructure that supports Society by facilitating the flow of spatial information and analytical technology between participants". Critically such systems must ensure the flow of information to all sectors of society and that the technology involved is available to, and can be easily integrated within, society.

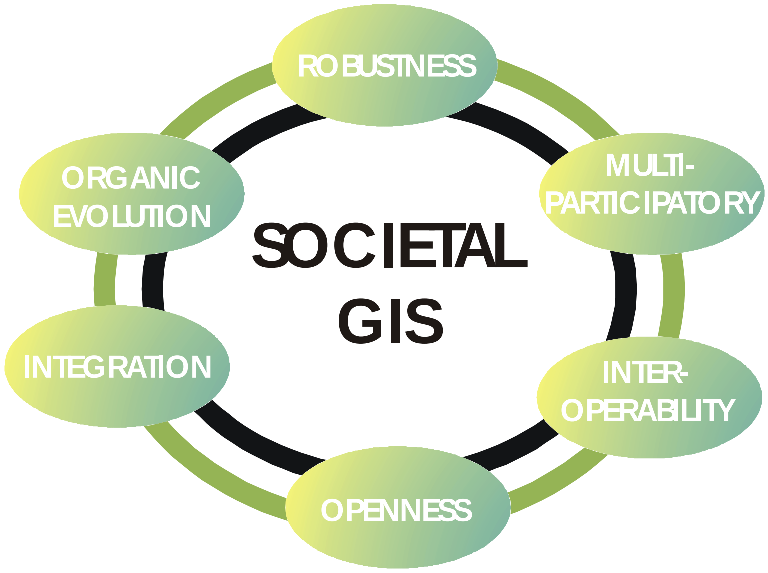

Figure 1: The components of Societal GIS

Characteristics of such systems include:

- Openness – both in terms of access (encouraging all parts of society to participate) and in terms of technology (facilitating open exchange of data and application resources).
- Interoperability – enabling applications and software held and developed separately to be integrated and work collectively.
- Robustness and availability – Societal GIS must be able to operate continuously on an ongoing, permanent basis (these are not emergency response systems that are switched on at the time of an event – they foster information flow continuously), they also need to be built to withstand and indeed operate through unspecified disaster.
- Capacity for Multi-Participation – information and resources do not flow

through Societal GIS in one direction (for example a local Government distributing information to its citizens), they flow in multiple directions in recognition of their inclusive nature.

- Capacity to Integration – information flowing through such systems is diverse and varied. The system must facilitate its integration and presentation as a complete whole.
- Capacity for organic evolution – catering for users and requirements that are never clearly specified or defined, such systems need to be capable of evolving as society evolves and to be able of rapid expansion to meet new challenges.

These are very high aims. Open, flexible, robust, inclusive, evolving – are such systems really practicable?

SOCIETAL INFORMATION SYSTEMS - THE PROMISE OF GIS WEB SERVICES

Geography and GIS technology have long been recognised as an integrating sciences based on the ability to bring unrelated layers of information together through common, shared location and to analyse and visualise connections and relationships between them. However in the past GIS has been hampered as, the complex nature of spatial modelling has tended to be addressed in ways that alienate or separate the technology from the community at large. Unique data structures and computation complexity kept GIS a rather exclusive science, separated even from other information system technology. Data volumes and network bandwidth made transfer of GIS data and results hard.

Such barriers have slowly been removed with the development of new storage techniques and increased conformity to general IT practices and standards. In the last two or three years increasing interest has been focused on the development of GIS Web services as a way of furthering this progress. Is Web services technology ready to meet the needs of Societal GIS?

A Web service is simply a software component that can be accessed across the World Wide Web (WWW) for use in other applications. Web services are therefore another form of distributed computing architecture, of which there are plenty (Common Object Request Broker (COBRA), Distributed Component Object Model (DCOM), Electronic Data Interchange (EDI)). All these architectures have the same basic aim – to improve the flow of information across networks, to enable programs in one environment to communicate and share data and functionality with programs in another.

Earlier approaches, though technically elegant solutions, suffered either because they were supported by a relatively small section of the IT industry and failed to garner widespread acceptance, or because they were complex and required a level of tight integration that was impractical for linking applications other than in large internal corporate Intranets. This limited their applicability to Societal Information systems. The Web Services architecture differs from these earlier approaches by adopting the ubiquitous World Wide Web (WWW) as the common network backbone.

Web services are both discoverable across the Web and deliverable over the Web – key steps towards making them openly accessible and encouraging wide and universal participation that is demanded by Societal GIS. Anyone with a web connection (which now not only includes those with PCs, but increasingly those using web enabled wireless devices – PDAs, mobiles, etc.) can access and utilise Web services enabled applications. The ubiquity of the Web bridges technological differences and enabled Web services as a general approach to garner wide and sustained support.

But the Web, at least initially, was never envisioned as a distributed computing environment across which applications can be joined and run – it was primarily designed as a client server environment in which known client software could establish dialogue with servers and retrieve and browse information from the server through fixed HTML Web pages. Web services work in a very different manner. Fundamental to Web services design are the concepts of Publish, Find and Bind that can be used to describe the basic relationship between service provider and client.

A service provider can *Publish* a service that they wish to release in proscribed format to a Internet portal. Publishing the service identifies its existence to potentially entirely unknown and, at the time of publishing, undefined clients and provides details of how a client can communicate with the particular service.

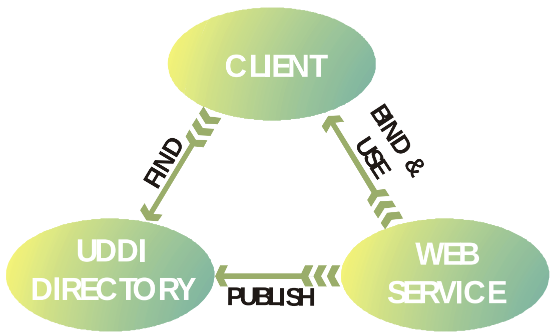

Figure 2: Web Services relationship - Publish, Find, Bind

Clients can search and *Find* published services in a similar way as popular Internet search engines are used to find Web pages. At present searches are more often than not undertaken manually, however the Web services architecture permits them to be undertaken automatically, so an application realising that it needs a particular function or dataset could search for and select remotely published services that meet its requirements.

Published information for the selected service provides the client with all the necessary detail required to *Bind* to, or connect and use the service including where and how to invoke it and parameter definitions. The service may be information presented on a screen (as with traditional Web pages), raw data, a function, a complete application or any combination of these.

This Web services model has significant consequences for Societal GIS. It provides the flexibility necessary both to enable services to be provided for users and tasks that are not known or clearly defined, and, to permit evolutionary development of applications to meet changing circumstances. Loosely bound and often highly componentized, Web services greatly facilitate rapid development and deployment of technology. The architecture permits such components to be served independently – users that may be entirely unknown to the originator of a service can find it independently and snap services together to develop solutions that meet their own needs (also unknown to the service provider). The end result may in turn be served as an entire new Web service.

In addition, this design model provides a degree of robustness necessary for Societal GIS. Components and data making up applications can be searched across the Internet

– if one service fails, it can, at least in theory, be easily replaced with another. Web services build on the dispersed nature of the Web to provide robust backup and disaster facilities that would be punitively expense to establish with traditional technology.

This is feasible only through focus on standardising the messaging between services as opposed to standardising the application providing or consuming the service. Regardless of the kind of program or software executing the service, as long as the description of how to access it, input and output data formats all conform to a published standard, the application will be able to communicate with others. Web services therefore depend on a number of developing Web protocols including, eXtensible Markup Language (XML), Simple Object Access Protocol (SOAP), Universal Description Discovery and Integration (UDDI) and Web Services Description Language (WSDL).

The World Wide Web Consortium's (W3C) (www.w3.org) XML protocol has been adopted as the de-facto standard for describing data transferred in Web service applications. Now widely established throughout Web computing, it owes its success to its flexibility – defining a syntax with which data descriptions can be defined rather than attempting to describe all forms of data itself. In this way XML has been able to be adopted by a variety of different vertical markets each agreeing their XML compliant definitions or schema. Thus, for spatial features, the Open GIS Consortium (OGC) (www.opengis.org) has led the development of Geographic Markup Language (GML), an XML schema designed to provide a cross-platform description for spatial data. Since its launch in March 2001, this effort has been gaining wide support within the GIS community. The standard is still evolving and work within the OGC by leading GIS and IT vendors such as ESRI, Intergraph, Oracle, Sun Microsystems, and key users, is continuing, with the goal of enhancing this standard to allow for complex commands and very large datasets. OGC is working on similar Web map server specifications.

XML also forms the basis of SOAP and WSDL. SOAP is designed as a standard envelope for delivering method invocations – basically a means of wrapping an XML document so that the recipient knows what to do with it on receipt. SOAP enables an XML statement to be sent over HTTP to a Web service and provides a clear mapping between parameters and function calls. WSDL is another W3C standard which defines a template to be used for describing a service. This tells the client what the service offers and in detail how to create and interpret both request and response. It defines the methods available, what their parameters are, parameter types and the nature of the output generated. WSDL is used by service providers to publish information on their service. UDDI represents a standard Web based directory of services – in effect a yellow pages of Web services. Though it is not necessarily a requirement to publish WSDL documents to UDDI, doing so avoids the need to hardcode service location and parameter details in to client applications giving them greater flexibility in the event of a particular service being temporarily out of action.

This concentration on standardizing the message rather than application at either end enables Web services to offer robust inter-operability between different platforms and applications – a key component of Societal GIS.

EXAMPLES

Web Services appear at least in theory to be able to provide many of the characteristics demanded of Societal GIS – open, interoperable, encouraging multi-participation, robust availability and capable of easy, rapid organic growth. Is this converted into practice? Though a relatively new approach, there are an increasing number of examples where Web services are being deployed to create what may be described as Societal GIS.

Spatial Data One-Stop – Joining up Spatial Resources

Work on Spatial Data Infrastructures (SDI) whether at a national or global scale has been going on for a number of years. SDI ensure an awareness and compatibility of data between organisations that are essential prerequisites for Societal GIS. In the United States, the Federal Geographic Data Committee (FGDC) has been working on the development of the National Spatial Data Infrastructure (NSDI) in cooperation with organizations from State, local and tribal governments, the academic community, and the private sector. The NSDI encompasses policies, standards, and procedures for organizations to cooperatively produce and share geographic data. A Web Service based portal, www.geodata.gov, launched on 30 June 2003 is now providing a gateway, a one-stop shop, for accessing the data, procedures, applications and projects that have been brought together by the NSDI.

Built by ESRI, Inc. within just eight weeks the Geodata portal is designed to be open and interoperable with virtually any GIS data set and service. It incorporates standards from OGC, ISO, FGDC as well as Web and computing industry. The portal provides a single point of access to services hosted by hundreds of different participants from across the spectrum of government, national and international organisations and the academic and private sector. Not only does it simplify the search for data, it provides rapid access to applications, projects, metadata, viewing engines, best practice notes and projects providing a central open geospatial resource.

The resources accessible through the Geodata One-Stop portal are vast. The aim is to lead users to data that they are searching for within only two or three clicks of the mouse. Information can be access in a number of ways:

- Categories – ways to organise data, applications, best practices, data models, projects and users by common topic or theme. Such topics include things like Biology and Ecology, Cadastral, Oceans and Estuaries. Categories provide a route to link, view and combine data from multiple data services, to access hosted application services and project web sites, and download and work with federal, state and local data model templates.
- Metadata search tools – these access metadata routinely harvested from clearinghouses distributed through out the United States. Search tools provide an easy interface based around three simple question - Where? What? When?
- Map Viewer – a sophisticated map viewer provides interoperability for data held in a wide variety of different formats and permits data to be selected, viewed and queried. There are over 15 independent map viewers that can be downloaded for viewing data in different formats.

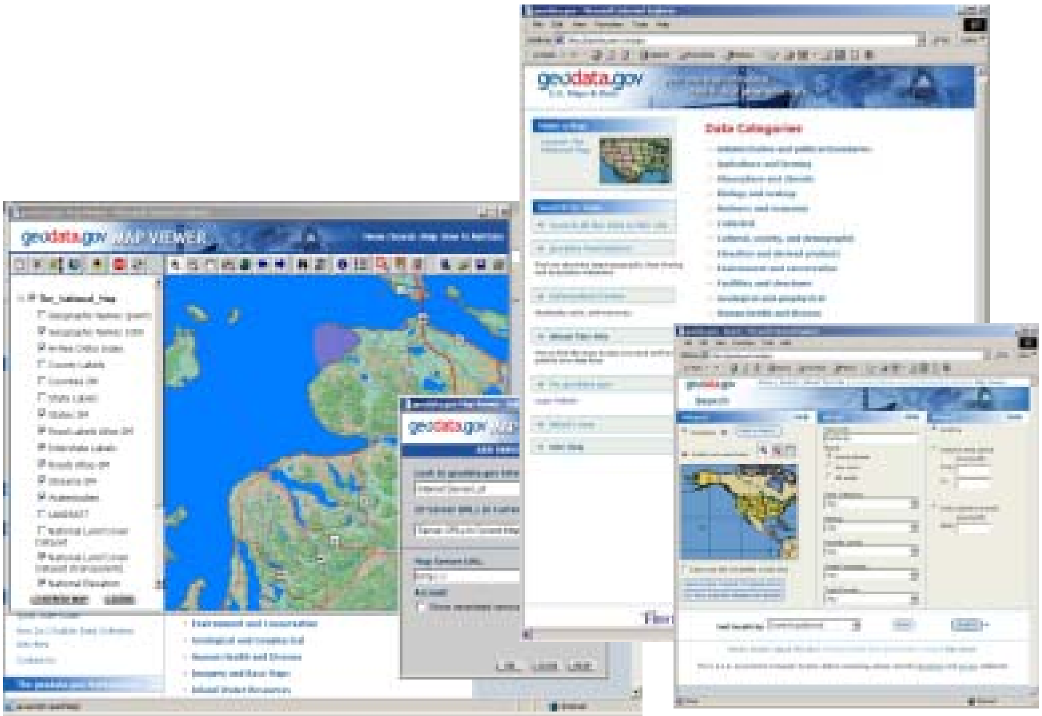

Figure 3: Geospatial One-Stop providing access to USA’s spatial data

The Geodata One-Stop portal demonstrates clearly the power of Web services to provide centralised point of access to diverse, dispersed information resources. Maintaining services as discrete independent resources and linking them with the Web, building on the vision of shared, interoperable information, the system provides a clear indication of the road ahead for SDI and societal GIS.

Mapping the Truth about SARS

From March 2003 for a period of at least three months a SARS epidemic originating in Southern China spread around the world and caused fear and widespread disruption. The epidemic claimed thousands of lives and resulted in the isolation and quarantine of thousands many more with severe economic implications for countries in Asia and leading cities around the world. As in all such emergencies fear, confusion and lack of access to reliable information compounded an already difficult situation. One of the major initiatives of the World Health Organisation (WHO) in helping governments tackle the situation was to encourage release of daily, reliable infection statistics and information.

The SARS GIS portal (http://www.esrichina-hk.com/SARS/Eng/sars_eng_main.htm) was established by ESRI China (Hong Kong) Limited to visualize the geographic distribution and spread of the disease based on statistics from WHO and the Hong Kong Government. As such it helped cut through the fear and confusion and provided a reliable source of information about the distribution and development of the disease. It became a centre of information for both the public and press in the region and around the world, mapping information as it was received from the health organisations and enabling the location and spread of the disease to be mapping. Throughout the crisis the site produced over quarter or a million maps and at the high of the pandemic was producing maps at a rate of 12,250 per day.

The core system was up and running in less than two days. This feat can be attributed to the fact that it was based on existing Web service functionality. GIS web services provided access to a robust, ready and deployable set of functionality that could be easily modified to create the necessary functionality for the system. An existing Web service provided local, regional and world map services and related navigation and print tools. A series of small routines were developed to automatically geocode daily updates of official suspect, infected and recovered SARS cases. Existing Spatial search, Query and Identify Web services were used to complete the initial portal.

As the epidemic progressed and was controlled additional Web functions were added to provide historical trend analysis and snap shot capabilities.

Figure 4: Sample screen shots from SARS Mapping Portal

What is important to take from this example is the speed with which the system was deployed in the event of very unusual circumstances. It combined data being produced from a number of different organisations and existing Web services which could be easily evolved to meet the rapidly developing situation.

Accessing the Environment –Serving the UNEP's data archive

The United Nations Environmental Programme is a vast organisation with hundreds of different offices, programmes and groups. Individual programmes and projects hold and maintain very large quantities of environmental, social and economic data. Making this available in an accessible form is an enormous undertaking, particularly as much of the data is core fundamental data and statistics which may be used by different researchers (within and outside the UNEP) in hundreds of different ways.

In 2001, the UNEP launched a Web services based UNEP.net initiative (www.unep.net) designed to help its own staff and those outside the organisation access, locate and work with its datasets. Many data sets are very rich, providing statistics in tabular or spreadsheet format as well as maps, graphs, charts and summary reports. Data is organized around a number of thematic (climate change, freshwater, mountains, socio-economic) or regional (Arctic, Africa, Europe) portals as well as a GeoPortal which provides access to map and tabular data. The Web service based portal works by providing a standard point of entry to access existing databases and web services developed and managed by different parts of the organisation. This is fundamental as it means that investment in the platforms undertaken by different programmes and projects is maintained, as there is no need to redesign these sites.

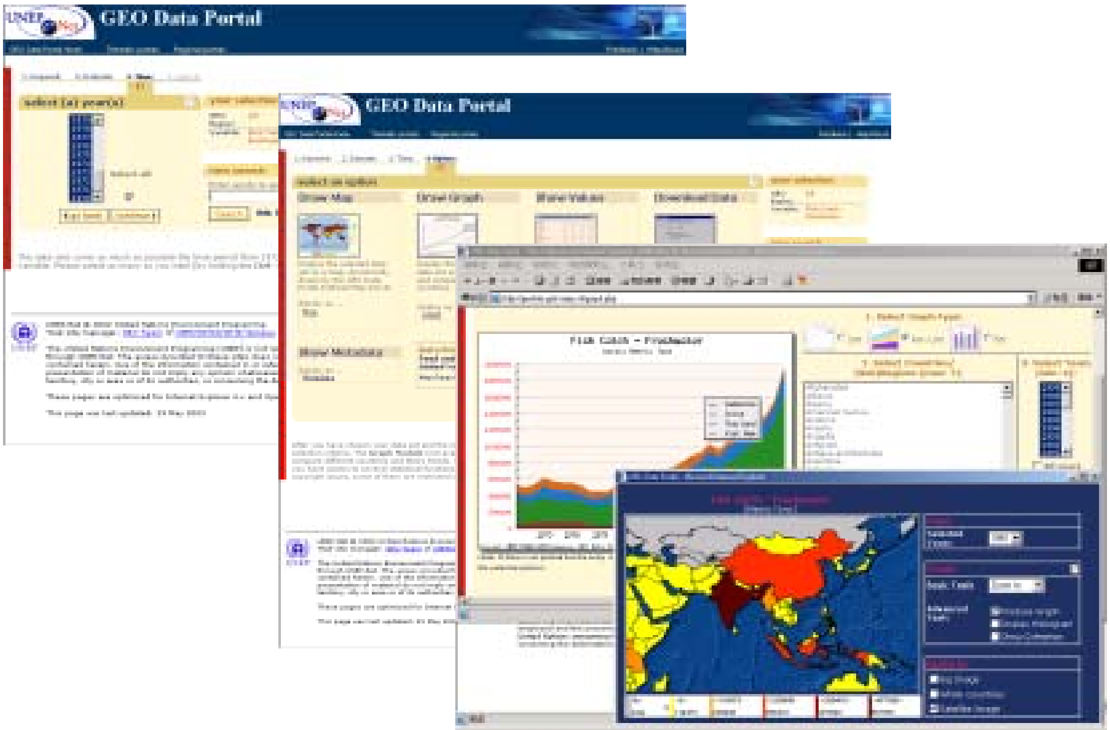

Figure 5: Examples of Multi-Agency Participation through UNEP.Net

The UNEP.net portal provides a classic example of the multi-participation that can be encouraged by Web Services. It not only supports better communication and usage of resources by parts of the large and global UN organisation, it supports how these are used by countless other users – Governments, researchers, pressure groups and individuals of which the staff developing each of the individual systems that together make up the UNEP.net are entirely unaware of. Increasing participation also increases the potential for interoperability as groups separated by distance or organisational boundaries realise common applications and aims.

CONCLUSION

With the development of the Web services architecture there is a clear trend towards GIS becoming more open, robust and interoperable. Retaining its unique ability to integrate diverse data through shared location, GIS Web services offer real potential for meeting the demands of a more encompassing, wider Societal GIS vision that will bring significant and lasting benefits to the way information flows through society. Some words of caution are however relevant at this stage.

Firstly as more and more information is made available through what remains relatively complex technology care should be taken that parts of society are not inadvertently being excluded or disadvantaged. Certainly the Web provides a mechanism for universal, rapid access to information at a scale that has never been seen before. It is also undeniable that the Web, GIS and computing technology in general has become easier to use and more accessible. There are however still large segments of society that, for one reason or another, cannot take advantage of this. Reasons for this vary - limitations of technology available, lack of bandwidth, poverty or lack of training, even age (degree of confidence and proficiency with Web and computer applications even in countries with high computer literacy remains highly stratified by age). Web services technology certainly offer scope for Societal GIS, but technology itself needs to be accompanied with strenuous effort to address the technological divides that still exist in society in whatever form and wherever they appear.

In addition, Web services are new and rapidly developing and some may say that they are not yet ready to be implemented in the scale of systems that Societal GIS would necessarily require. Much of the discussion focuses on two issues: Internet Security, and Web services business model. On security, progress is certainly being made as the Web services model is increasingly incorporated in mainstream computing products such as Microsoft's .NET and Sun Microsystems's J2EE. What is perhaps more of an undertaking is the shift required in corporate and organisational thinking that will permit expansion of the sharing, interdependent methodology on which Web services is based. This is new and goes against much of traditional organisational practice. It will take time to develop. Web services offer a viable solution in which sharing and interdependence can be promoted and one in which the benefits of such an approach can be clearly demonstrated.

It is also important to ensure that Web services remains open and not dominated by vendor specific rivalries. The architecture is entirely dependent on standards. Standards are difficult and time-consuming to work out, particularly in the diverse and complex world that Societal GIS addresses. This requires collaborative effort and vision on the part of many companies.

Perhaps most importantly in all of these areas, and for the success of Societal GIS as well as the Web services architecture, there is a need for participation. One of the reasons why GIS Web services form such a useful model for Societal GIS is the fact that it is dependent on multi-participation. This breaks down traditional roles of provider and user – user can also become provider and visa versa. Web services and Societal GIS cannot succeed if only a few isolated organisations adopt this approach – they are multi-participatory systems – they will thrive on a willingness to participate.

The Web services model is perhaps the best chance for fulfilling the promise of GIS and developing truly Societal GIS. Issues remain, but GIS Web services provide a useful architecture and real demonstrations of successful working Societal GIS based on it are beginning to emerge. Sustaining this development and bringing potential to fruition now rests on widespread and committed participation.