GEOMATICS FOR COLLABORATIVE INNOVATION

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ABSTRACT:

Twenty-first century systemic global change in health, water, environment, energy, business and socio-economic structures is challenging our communities' management of resources. For a community to adapt to this systemic change, while maintaining and even enhancing its economy and quality of life, the World Economic Forum has recognized the need for new approaches to enable collaborative innovation (CI) and related action among both the leadership and concerned members of the community. Many see the web as an approach to CI and as a new form of creativity machine that can augment our intelligence.
This paper outlines the concepts of an approach to CI based on asset mapping and how it has been supported through a web-based technological framework. Based on the experience using the framework in designing and building over 50 systems that incorporate asset-mapping CI, it is clear that CI takes many forms. We illustrate some of these forms through specific examples in environment and socio-economic development and planning. We conclude that it is not possible to build a single set of tools to support CI. Rather a framework and a set of meta-tools is needed which can be used to build tailored systems to fit specific situations that arise when web-based collaboration is to occur.
The Centre for Community Mapping and the Computer Systems Group at the University of Waterloo are using the Web Informatics Development Environment (WIDE) to support collaborative innovation, with services related to temporal and spatial data, distributed role-based access controls, reporting, document management, social networks and other collaboration tools. Two examples are discussed:

- Invasives Tracking System, developed for the Ontario Federation of Anglers and Hunters for agencies and the general public, with facilities for capturing, identifying, mapping and reporting on invasive aquatic and terrestrial species in search, discovery, remediation and monitoring stages of invasives management and for capturing, reporting and tracking of remedial action.
- NewsAtlas, a community development service for Family Service Toronto, with an open and accessible web based asset mapping process that puts mapping tools into the hands of the groups who have the least resources in the community.

WIDE is an example of the type of meta-tools that are needed. Lessons learned from WIDE are being applied in the creation of WIDE 2.0.

1 INTRODUCTION

Twenty-first century systemic global change in health, water, environment, energy, business and socio-economic structures is challenging our communities and us as individuals. For a community to be resilient in the face of these difficulties and adapt to this systemic change, while maintaining and even enhancing our economy and quality of life, new approaches are needed to enable intelligent collaborative innovation and related action among community leadership and concerned and interested community members. We need to harness the power of the web to augment our intelligence as a new form of creativity machine (Vinge, 2006).

As an example, the World Economic Forum (WEF) (World Economic Forum Annual Meeting 2008; The Power of Collaborative Innovation, n.d.) recognizes the need for an effective approach to collaborative innovation in the aftermath of the global economic crisis as local and international communities are becoming more and more interdependent. The WEF has recommended that communities both geographic and virtual re-examine their strategies based on new evolving networks and forms of collaboration. Thus public-private partnerships and smaller-scale region or city-driven initiatives must move away from one-size fits all arrangements and adapt to the re-design and rebuild of their structures and processes related to both local and global community interactions, resource exploitation and governance.

Such related actions among participants in communities of practice and geographic communities must be supported by services providing an information infrastructure that is easily accessible through a medium such as the World Wide Web. The focus of this paper is to examine experiences with collaborative innovation within the context of the new modes of communication that have arisen through the development of the Internet, Web and tools such as social networks. The Web Informatics Development Environment (WIDE), a set of technologies designed and developed by the Computer Systems Group at the University of Waterloo (UWCSG), has been created to provide this type of service and can be easily tailored to support specific collaborative activity.

Such collaborative innovation services could be used to address many problems that involve communication and cooperative action within a geographic community or community of practice.

Over 50 web-based information infrastructures developed by UW-CSG and the Centre for Community Mapping (COMAP) and based on the WIDE technologies have been created to provide services that support collaborative innovation in many application areas.

This paper describes a framework to support the social and technical principles which underlie current and future web-based CI. It will also present examples of web-based systems for CI in specific fields such as environment and socio-economic development and planning.

2 UNDERSTANDING COLLABORATIVE INNOVATION

Collaborative innovation refers to a process that involves assembling a team of people to explore and act upon change in an idea or situation (Chesbrough et al., 2006). The span of collaboration is usually a virtual community of practice or interest, or a geographic community (Wenger, 1998). The individuals that compose the team can represent themselves, different departments in a single organization or different organizations. A team often works in a mediated environment where responsibility for actions can be devolved to specific team members. These responsibilities can be specified through one or more contracts among individuals and organizations.

Collaborative innovation teams have a collective vision and wish to work together by sharing ideas, information and work. Team members share directly rather than through a hierarchy, although each member may represent the views of the hierarchy to which they belong. Any collaboration must have four essential elements, which are:

1. sound ethical principles;
2. trust and self-organization;
3. universally accessible knowledge; and
4. honest and transparent operation.

Although organized collaborative innovation has been recognized as early as Benjamin Franklin's "Junto" organization (Junto, n.d.), today most work of this type, relies on modern information and communications technology (ICT) such as the Internet, e-mail, Web and more recently social networks.

What else is needed to make collaborative innovation effective? Collaborative innovation requires shared knowledge of the resources or assets that are available within an application domain or context and then using that understanding to implement actions such as operational and structural decisions.

Collaborative innovation can be viewed as a two-step process where members of a geographic or virtual community

1. produce an inventory of assets and share this data across one or more communities; and
2. collaborate and act on that asset knowledge to:
   (a) recognize additional "undiscovered"assets;
   (b) produce value and change; and
   (c) create new assets related to the change.

Basically the participants share knowledge and add value to that shared knowledge through a collaborative set of tools which are formed into social networks that operate under various constraints such as access, time and mobility.

In many fields, the concept of creating an asset inventory is called "asset mapping" and the new value and assets produced from the collaboration are often called emergent properties. Most work in this field to date has focused on "static" asset mapping and has only begun to investigate the methodology to keep the asset inventory current or "dynamic" and in taking action over the growing asset base. Further research is needed into an organized approach to on-going collaboration, dynamic asset mapping, and value production, although this lack of a theory of collaborative innovation should not stop its use. In this paper we outline a novel asset-mapping driven approach to web-based collaborative innovation based on our experience in designing and implementing over 50 such systems.

3 ASSET MAPPING, CI AND THE WEB

There are many facets to collaborative innovation using ICT and based on an asset mapping approach. In this section we analyze this phenomenon and try to understand its constituents and related properties. Basically the participants share knowledge and add value to that shared knowledge through a collaborative set of tools under various constraints such as access, time and mobility.

3.1 Constituents of Asset Mapping CI

3.1.1 Shared knowledge There must be a collection of shared information or knowledge, often called a database, knowledge base, inventory or asset map, to provide a basis for collaboration that takes advantage of intelligent software agents to manage redundancy (Alencar et al., 2003). For example, an environmental group interested in tracking and eliminating invasive species in a region would likely start with a database of all such known species in the geographic area and the protocols associated with their identification and removal.

3.1.2 The Collaborative Canvas Information about these assets and input to and results of the collaboration can be presented through shared canvases or interfaces. The shared canvas can provide many different tools such as a data report, input to databases, e-mail, audio, video, pictures, text, maps (geomatics), short messages (Twitter tweets), blogs, and wikis to name some examples.

3.1.3 Access controls Collaboration requires that a group forms around an idea or situation with the objective of working together. The group is self-limiting by expertise or interest although it may grow or change its composition as the collaboration forms and changes, and new expertise is needed or more individuals become interested. By its nature collaboration is not completely open. Therefore there must be moderators who manage the group composition and delegate authority to members of the group related to responsibilities. These moderators must be given a set of tools not only to enable the collaboration but to admit participants with responsibilities, so-called role-based access controls (Bertino et al., 2010).

3.1.4 Social Networks Social networks can be viewed as a set of tools from the collaborative canvas that allow sharing and collaboration over the asset base with responsibilities usually delegated through role-based access controls. There can be many different types of tools that are used as components of the social network as already described including maps (geomatics), input forms, reports, text, video, pictures, audio, wikis, blogs, and asset repositories.

3.2 Properties of Asset Mapping CI

3.2.1 Collaboration in Time Collaboration can occur asynchronously or synchronously (real-time). Asynchronous collaboration is more common because contributors do not have to agree on a time to meet. The collaborators can contribute through e-mail, maps, wikis, blogs, Web forms and other similar mechanisms.

Synchronous or real-time collaboration requires the presence of two or more parties to the collaboration. Of course all the collaborators could be in the same room or share the map and associated communication channels over the Web.

3.2.2 Mobility Mobility adds a new dimension to collaboration as now the collaboration and the creation of value can happen while participants are on the move.

3.2.3 Adding Value Once the collaboration begins, the active collaborators through working together using the shared assets and collaborative canvas, add value since they create more information and knowledge or assets, which are usually added to the asset base. These additions are called emergent properties. Rich emergent properties often arise when diverse groups form communities of practice.

4 IMPLEMENTING ASSET MAPPING CI

The UWCSG and COMAP have undertaken joint research in developing meta-tools and approaches to building web-based information systems to support collaborative innovation based on dynamic asset mapping. This work has resulted in the Web Informatics Development Environment (WIDE) technologies and over 50 web-based systems many of which support different forms of collaborative innovation.

The meta-tools in the WIDE include services related to temporal and spatial (mapping) data, role-based access controls, reporting, document management, social networks and other collaboration tools, that is WIDE implements tools that support the concepts in the previous section. This joint research program has a number of goals namely to:

1. develop data models and corresponding databases for asset maps in different domains;
2. create meta-tools to simplify the production of interfaces, access controls and social networks;
3. create interface and social network frameworks to asset maps to support powerful and purposeful collaboration;
4. create interface frameworks to asset maps to assist with collaborative and dynamic asset map updating;
5. create interface frameworks to interrelate information maintained by different communities of practice to enable synergistic benefits; and
6. produce meta-tools that can be used and maintained by the collaborators.

Participating organizations are provided with social network services that support self-organization among participants by promoting opportunities to share knowledge with other participants with common interests or goals. By combining dynamic asset mapping with social network services, communities of practice can collectively communicate to discern opportunities for asset management.

Since collaborative innovation requires advanced technologies to integrate known and novel web services, an efficient approach to building and testing such complex technologies with direction from community of practice participants is needed. The toolkit based on the WIDE technologies offers approaches that are simple to use and to change - programmers are rarely needed.

In the WIDE context, ”programming“ has effectively been replaced with a declarative methodology thus making it possible to provide a wizard or forms-based approach to building Web-based systems. This approach allows the technical team to develop web-based information systems about 10 times faster than more traditional methods.

COMAP and UWCSG and the users completely engage during the entire specification, design and implementation cycle and use an iterative approach within the context of the WIDE technologies to create complex web services. The approach is iterative in that once users operate a version of the system, they may actually change the specification on the fly, thus affecting further design and implementation.

5 ASSET MAPPING CI EXAMPLES

Different forms of collaborative innovation depend on factors such as community scope, degree of cohesion among community members, and type of knowledge exchanged and can lead to different types of communities (Janner et al., 2008). The WIDE toolkit has been used to support many different forms of collaborative innovation with varying sizes of geographic and virtual communities and different degrees of community coherence based on common goals. Some specific projects and related approaches are described in this section to illustrate our current thinking. The examples show:

1. Collaborative geomatics (mapping);
2. Collaborative dynamic asset-mapping for communities of practice;
3. An inclusive service framework for authoritative and volunteered content; and
4. Collaboration through custodial distribution of authority to publish.

5.1 Collaborative Geomatics (Mapping)

Collaborative geomatics consists of a common mapping canvas where communities can have discussions and communications about evolving local issues and collaborate in using applications for local data capture, analysis and reporting. COMAP and UWCSG, have built a mapping interface and database (WIDE image server, with W3C and Open Geospatial Consortium services: WMS, WFS, VML, and SVG) which can serve thematic and highly resolute airphoto data for Southern Ontario. To ensure that all of Ontario is served and easily searchable Invasives Tracking System (ITS) uses GeoBase satellite data and a Lambert projection. Collaborative geomatics services have been used extensively in the Invasives Tracking System.

The ITS was developed by COMAP and UWCSG for the Ontario Federation of Anglers and Hunters (OFAH) and will be launched

in the spring of 2010. OFAH has been Ontario's 'hot-line' for the reporting of invasive species on behalf of the Ontario ecosystem conservation community of practice since 1992. The ITS is intended to be a hub for citizen scientists and professional organizations involved in invasive species issues. The goal of the ITS project is to monitor invasive species presence and to track invasives control projects in support of appropriate decisions with regard to restoration priorities and techniques.

The ITS web mapping application was developed to enable citizen scientists as well as conservation professionals to report sightings of both aquatic and terrestrial invasive species and accurately map their location directly on high resolution air photography. The resulting system has facilities for:

- tracking, mapping and reporting on invasive species in search, discovery, remediation and monitoring stages of invasives management,
- and for capturing, reporting and tracking of remedial action.

The ITS project is a database and a web-based set of applications that accesses spatial data and information in real-time from distributed sources over the Internet. The ITS was planned to permit the southern Ontario conservation community participants to work collaboratively by:

- entering spatial (polygon) and tabular data, photos and documents about their invasives species sightings and ecological restoration projects as well as exporting entered data to external geographic information systems;
- querying the database to meet their needs for tracking invasives species' sightings and specific restoration projects;
- reporting and summarizing monitoring data about invasives species' sightings and restoration projects by numerous parameters; and
- implementing adaptive management of ecological restoration practices based on an ever-expanding base of knowledge about the factors that contribute to successful ecological restoration projects.

Expected benefits of the web mapping application include:

- Increased motivation by volunteer citizen scientists to report sightings of invasive species
- Increased accuracy of sightings, both for location and identity of species
- Accurate mapping of invasive species sightings to facilitate follow-up remediation or restoration activities by professional staff from resource management agencies
- Performance management system to monitor impacts of restoration activities (e.g., invasive species removal)
- Increased public awareness of the invasive species threat and enhanced motivated to take preventative action
- Increased public awareness of invasive species using information contained in invasive species thematic maps (verified sightings)

The ITS is acknowledged to be the leading effort in shared information infrastructure for cross-scalar provincial reporting on invasives species management in Canada. WIDE mapping supports the capture of fine-scale information using standard protocols, which can then be used to augment existing GIS data to permit landscape GIS analyses. WIDE services can increase the value of information management resources by integrating numerous data sources in geographic space in order to provide enhanced direction for asset management decisions. These processes can be manual or automated.

5.2 Dynamic asset-mapping for communities of practice – Family Service Toronto

Community participants will take the time to organize and share community perspectives, reporting and analyses using collaborative geomatics to populate maps with text, data and media, if the members of the community see value returning to their community through their active participation. This process known as "dynamic community asset mapping" is an extension of community 'asset mapping' as initially defined by John McKnight and John Kretzmann (Kretzmann, 1993) and now widely practiced by communities in North America.

Family Service Toronto (FST), a city-wide social service agency that offers family counselling and community development services, and COMAP have recently formed a partnership to build a portal to support the FST Building Inclusive Communities Division, Community and Neighbourhood Development Unit (CND). CND is funded to facilitate a community development planning project in an area of Toronto that includes established social service agencies, grassroots groups, businesses, faith groups, residents and other interested parties.

The goal of this Community Development Project is to create and implement a community planning process, which is fully inclusive and rooted in best practices of community development and empowerment. The main objective is to increase the amount of community planning that is done collaboratively, inclusively and intentionally. FST believes that one of the best tools to assist in this process is the development of an "open" and accessible web-based asset-mapping process that puts mapping tools into the hands of the groups who have the least resources in the community.

The evolution of grassroots groups from (horizontal) community circles to coherent organizations with capacity to collaborate with (vertically oriented) external resources is seen, by professional Toronto community developers, as an evolution to viable community governance. Community asset mapping in the pursuit of improving assets and capabilities through collaboration, falls short of viability in situations where governance is weak. In the absence of a coherent system of governance, access by grass-root groups to external resources, by default, falls under the control of the external organizations (that do not necessarily reflect the involved input of community residents). The objective here is to develop capable and effective innovative neighbourhood collaboratives to which resources could be devolved by external agencies.

In order to create a forum for collaboration and dynamic asset mapping, COMAP is building the NewsAtlas portal with FST as system custodian. COMAP uses the newspaper-map metaphor to encourage maintenance of current community information. NewsAtlas will pilot community development work in four Toronto neighbourhoods in conjunction with service organizations that participate in FST. The NewsAtlas service architecture has three

components: (i) a public view with organized news pages, map-layer based search facilities, calendars, classifieds and a service directory (ii) a secure social network service for participants who develop and publish NewsAtlas content and (iii) an underlying database that holds content and application services.

NewsAtlas will start as a community asset mapping initiative and be maintained as a community news source with departments and sections providing: entertainment, arts, sports and recreation content, lifestyle and spiritual content with mapping and event calendars. The process is available to community groups and social service agencies at no charge which levels the playing field for groups with little or no resources. At the outset we envision a Toronto wide service with a list of neighbourhood 'front' pages, which will mimic a city-wide newspaper. All content will be searchable city-wide by drawn map area in combination with powerful search tools that support searches by content, space and time.

The NewsAtlas media services will contribute to building viable community governance. NewsAtlas is intended to bring on-going service sustainability in terms of content, community participation and social enterprise revenues, all to address the main project objective: to increase the amount of community planning that is done collaboratively, inclusively and intentionally.

5.3 Service frameworks for authoritative and volunteered content

Clay Shirky's (Shirky, 2009) comments on 'cognitive surplus' suggest a huge unused capacity that could be channeled for social benefit by new social media frameworks. However, academics, professionals and other authorities strenuously resist the 'wisdom of the crowd' for many and often good reasons. COMAP and UWCSG are implementing systems that provide for both authoritative and volunteered content in a manner that maintains clear distinctions. These novel approaches organize the chaos of social network services for community benefit. To encourage self-organized learning networks COMAP and UWCSG are developing user activated content subscription services. These services will permit users to find out about activities that interest them and to learn from the members of their social network that lead these activities. Users will be able to create subject based forums and invite selected members to discuss ideas and challenges.

The Invasives Tracking System (ITS) technical committee wanted a social network that is only open to the experts and related agencies. They reasoned that the general pubic may be confused and misconstrue volunteered content as being official content. Consequently, the ITS deploys a social network system consisting of groups, forums and authoring services that the agencies will use to share their experiences, as a learning network and to allow collaborative authoring and publishing of official and authoritative information used to help identify and control invasive species.

COMAP has developed a system with tools that permit the public and the ITS conservation community of practice to access an invasives species field guide, a sightings reporting facility and query service for approved sighting information. Only the ITS conservation community of practice, however, can report on a restoration project and export contributed tabular and spatial data.

A field guide of invasives species is provided (which is editable by OFAH personnel) with a complete listing for all invasive Algae, Fishes, Invertebrates and Plants.

A ITS Sightings link provides the user with the ability to select parameters (species common or Latin name, waterbody, 'geographic' county, Ministry of Natural Resources district, Conservation Authority, tertiary or quaternary watershed, drawn polygon, rectangle or circle search area, sighting date or sighting date range, confirmation status) and search for, list and map all requested sightings. The mapping service, supporting the sightings search facility, uses a novel application of Ajax technology whereby any parameter will list and map immediate results within a selected geography. The map bounding box and hence the selected zoom level is a search parameter. Additional parameters will further constrain the results.

All parties can access the 'Report a Sighting' service. Once a user has selected species type (Algae, Fishes, Invertebrates, Plants) a list for each species with thumbnail photo, a link to a Field Guide page and a 'Report a Sighting' link is presented for selection. The 'Report a Sighting' link presents a sighting report form tailored for context (Aquatic or Terrestrial) and pre-loaded with the selected species. Photos of the sighting can be uploaded. Map 'point' posting services allow the user to pin-point the location of the sighting using high resolution (zoomable, pannable) aerial photo mapping. A sighting confirmation process and administration services are provided so that OFAH can manage confirmations.

The ITS Community of Practice (CoP) can report on invasives management and control projects. Projects can be site (on-the-ground) related or public education or outreach in nature (off-the-ground). A project may have one or more sites where activities are performed. Project and site level photos and documents can be uploaded and site level activities and results can be recorded for the fiscal year of a project.

5.4 Custodial distribution of authority to publish

The NewAtlas system, in development with FS, the ITS, in development with the Ontario Federation of Anglers and Hunters and all other collaborative geomatics systems developed by COMAP and UWCSG have comparable access control challenges.

Both the ITS and NewsAtlas systems use a social network consisting of groups, forums and authoring services that the agencies will use to author and publish official and authoritative information collaboratively.

In both the ITS and NewsAtlas systems the right to participate in the application social network, contribute and report on data and publish content is distributed to participating organizations belonging to each community of practice. In all cases system security is managed by the content custodian. The custodian distributes the right to publish and secures agreement (a contract) from rights' recipients to conditions necessary for system security and integrity.

In the NewsAtlas, for example, instead of a single publisher there will be Service Directories of participating grass-roots groups and agencies that have access, rights and tools to publish. Participation in the neighbourhood Directory will be managed by the custodian, (FST in the Toronto NewsAtlas). The custodian will be able to delegate authority to publish to a participating agency by using administration services for the managed distribution of access (UserID/Password) to NewsAtlas publishing services for participating organizations. Participating organizations will be granted authority to publish to NewsAtlas through this mechanism. Participant organizations can use social network group functionality to create tool-enabled publishing groups. When setting-up their publishing groups, participating organizations will be able to select from three NewsAtlas tool bundles (i: business

directory information, ii: events and news and iii: mapped media content (photo, video, audio). The Participating organization will be able to invite individuals, who are registered with NewsAtlas, to access and use their group services. These individuals can then publish with the delegated authority of the participating organization.

Minimum conditions for the right to publish are: Agreement to appoint an organization‘s group moderator and maintain, in good standing, an organization‘s membership information for those members that publish on behalf of the organization.

Registered participants will consequently be able to (or enable their membership or affiliates to) access NewsAtlas content publishing tools and content management services for depictions of their individual or organizational assets. Groups and agencies, in turn, will have responsibility for:

- granting access to their membership and affiliates to tools for publishing on their organization's behalf; and
- maintaining the access rights of their membership.

6 RELATED WORK

The asset-mapping CI approach proposed in this paper contrasts with closed community efforts, which involve limited interaction, and both restricted knowledge of community assets and their value chains (Chesbrough, 2003). In the context of service systems, it has been suggested that open service-oriented models could use novel paradigms based on innovation (Maglio et al., 2006) and asset mapping.

Thinking frameworks have been proposed to help organizations focus their management attention, and enable users to participate in the innovation process (van der Walt et al., 2009). In addition, modeling approaches have been defined to describe innovation networks from a services system perspective and to address inter-organizational interactions (Janner et al., 2008). In comparison, our proposal focuses on a framework that supports the construction of web-based collaborative innovation systems based on asset mapping that can address both inter-organizational and general community interactions and resource exploitation and production.

In summary, the research described in this paper based on our experiences aims at defining asset-mapping driven approaches to the development of web-based intelligent collaborative innovation systems that promote explicit knowledge sharing needs among cohesive and global-scope communities.

7 CONCLUSION

This paper outlines the concepts of collaborative innovation based on asset mapping, its importance to the functioning of modern society and how modern web-based tools could be used to support this activity. Based on the experience gained in designing and building over 50 systems that incorporate collaborative innovation, some of which are described in some detail in this paper, it is clear that collaborative innovation takes many forms. Thus, it is not possible to build a single set of tools to support collaborative innovation. Rather a set of meta-tools is needed which can be used to build tailored systems to fit specific situations that arise when web-based collaboration is to occur. The WIDE technologies are an example of the type of meta-tools that are needed. Lessons learned from the construction of WIDE are being applied in the creation of WIDE 2.0.

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