Chapter 4

Collaborative Public Participatory Web Geographic Information System: A Groupware-Based Online Synchronous Collaboration to Support Municipal Planning

Muhammad Atif Butt, Syed Amer Mahmood,
Javed Sami, Jahanzeb Qureshi,
Muhammad Kashif Nazir and Amer Masood

Additional information is available at the end of the chapter

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Abstract

Co-PPGIS has a wide variety of applications like municipal planning, emergency response, public health and security, etc. The main focus of this paper is on the development and design of a web collaborative PPGIS (Co-PPGIS) infrastructure. As part of municipality's planning and management services, Co-PPGIS is developed for real-time map sharing application system. Co-PPGIS is an effective and essential online meeting system for supporting group collaborations on geographic information such as maps and imageries and capturing and sharing of local/domain knowledge in real time. Co-PPGIS permits amalgamation of geospatial data and collaborator's input in the form of geo-referenced notations. It incorporates coherent components such as map sharing, real-time chat, video conferencing, and geo-referenced textual and graphical notations. The study aims to focus on public participation and geo-collaboration facilitated with information sharing, interactive geo-conferencing, real-time map, and data sharing with tools to draw features or add annotation to the map while discussions, uploading documents, and live communication. Co-PPGIS provides an efficient and reliable platform that will significantly reduce the time to acquire, process, and analyze data. The significance of this study is to contribute to existing public participation practices, to municipal planning, to decision-making, or to geographic information science.

Keywords: PPGIS, GIS, GSC, participation, feedback, WWW, CSCW

1. Introduction

1.1. Study context

In recent years, providing public role in decision-making regarding spatial problems has developed an ease for geographic information technology adept in supporting collaborative spatial decision-making. According to Densham et al. [1], it has been stated that geographical information system is the technology to sustain PPGIS, but expert methods are needed to reinforce spatial decision-making in a collective way. Although now geographical information system and PPGIS are not prototype to assist multiuser associations, many approaches may require group-based involvement for decision-making. The idea of collaborative geographical information system, computer-supported cooperative work (CSCW), and collaborative decision support systems (DSS) was proposed as information technology to provide understanding about spatial complications and provide computer-based spatial decision-making [2].

Multiuser collaboration is playing its role in many works involving stakeholders from different departments and organizations, in which mapmaking sometimes play a main role for giving visual information for the support to decision-making [3]. Web technology is rapidly expanding its range and has made it possible to take decisions over the web. Due to demands for web-based open mapping, an Application Programming Interface (API) united with other information systems and CSCW tools has become more important for the support of real-time map sharing output. Accordingly, the development of map-based applications for real-time collaborative is one effective step taken by researchers who are efficiently working in many fields, e.g., emergency system, urban planning projects, municipality management, GIS data production, monitoring of urban sprawl and epidemic spread, and many more that assimilate collaborative role [4–9].

A concurrent approach is made for the support of collaboration among the users [6]; although, little work has been done on developing and designing such open-source software (OSS) which is based on online map sharing tools and support real-time collaboration. By assessing the researchers' work and their contributions from the literature review, this study aims to develop an outline about the significance of the execution of irreplaceable and sufficient methods, tools, and techniques to fill the gap in the research. Multiuser synchronous discussions and communications among the people and between the community and stakeholders sometime improve the understanding that shows an effective feedback and magnifies decision-making [10–14]. This paper actually shows a customizable framework used for an online system for collaboration with the installation of different web GIS, OSGIS, OSS-based tools, and open mapping APIs on geographic information to solve the issues that are related to emergency/disaster occurrence and municipal planning. Additionally, the study anticipates designing an open mapping API-based real-time collaborative synchronous infrastructure with the option of installing local data for improving the involvement of during debate. Some of these research prototype elements based on this kind of model are still in development procedure and in its starting stage in the house applicable testing.

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1.2. Study objectives

The study aims to develop a real-time map sharing mechanism and collaborative PPGIS (Co-PPGIS) and for collaborative assessment the amalgamation of other open source-based groupware solutions on an effective GIS-based meeting platform. The aim of this study was also (1) to assure that Co-PPGIS model will help to improve or increase involvement of participants and will provide assistance to decision-makers in reaching a final decision efficiently; (2) to explain certain facts or observations, i.e., core concepts, design and technology, etc., with an overview of enabling technologies for analyzing and designing a successful real-time map sharing framework; and (3) to describe a prototype development based on case scenarios that looks into integrating CSCW principles and open-source groupware tools with web-based GIS. In order to assist municipal planning and development through a better and effective decision-making process, the primary research goal is to develop a web GIS-based contemporary collaborative participatory infrastructure. In order to fulfill the main research's goal, this study will focus on achieving the following objectives:

1. To gain better and effective understanding of the PPGIS nature, its culture, its limitations, and basic requirements by modeling general as well as high-level participation requirements after proper and complete analysis of the municipal planning and development (P&D) process workflows and by reviewing the existing online PPGIS applications
2. To portray collaborative, real-time web GIS-based participatory infrastructure that can employ open-source geospatial data, standards, software tools, and web services

This research primarily encompasses the working mechanism of real-time collaborative web map sharing framework that is going to be addressed within a fixed time period.

1.3. Background and literature review

Increasing importance of the need for an effective public participation in a decision-making process during municipal planning and development is on the main focus in this section of study. Through the integration of GIS technologies, involvement of public or local stakeholders in decision-making can become more effective. Public meetings, which is one of the traditional methods of public participation, is integrated in some PPGIS projects to accumulate public ideas, values, and preferences [15]. Collaborative use of GIS-based services encompasses the involvement of public and planners in the decision-making process with geo-conceptualizing a map and accommodating public and planners to build local spatial knowledge and exchange ideas. In order to get instantaneous access and conceptualize the spatial information and participate in decision-making process, collaborative GIS-based services provide opportunities to local stakeholder [16]. An increased public participation can lead to a better and effective decision-making because the processes of decision-making and public participation have a direct relationship which means that better decision-making processes can also lead to an increase in a user's participation and vice versa.

1.3.1. Rationale on municipal planning and management through existing public participation

In almost every field of life, planning process has certain defined goals or objectives just like in developing a small- or large-scale municipal plan and has some objectives such as to make planning process accessible, to accommodate in the conveyance or dissemination of ideas, and to support the decision-making process. Participation of public in municipal planning and management, according to traditional methods, includes neighbor notifications, interviews, exhibitions, public meetings/focus group discussions, and public enquiries through telephone, letters, mails, fax, or public hearings [17, 18]. In order to disseminate the need of a proposed solution during public meeting, planners and decision-makers present their plans through PowerPoint or point boards which is still considered as one of the most commonly used participatory approach [19]. In western world, public meetings are organized in order to accumulate feedback of public during planning- and development-related workflows for effective and better decision-making. For example, in the United States and Canada, local governments and many municipalities necessitate a level of participation in their decision-making processes [18].

Table 1 reveals the issues and concerns that are commonly faced during planning- and development-related processes in existing practices of public participation. It illustrates or portrays the complete assessment of existing public participation practices related to communication channels, notification, access of information, and exploring spatial data of municipal projects. Li et al. [18] also disclosed several main issues regarding traditional public participation practices like inadequate access to the information needed for public input, for exchange of ideas or information, and for communication; there is a lack of essential or creative platform, restricted awareness mechanisms, and notification channels. Factors like "successfully revealing and educating the public about the program before hearing, proper planning and management of meeting, providing an understandable and media-rich demonstration of the issues and organizing a proper follow up" are those factors upon the success of public meetings depends.

Issues	**Concerns**	
Notification	Limited means, e.g., newspaper, flyer, etc.	
Communication channels*	Public meetings/public calls/information resource center	Formal/informal presentation
		Open talk with public
		Flat board displays containing preliminary design/model solution
Exploring spatial data	Using hardcopy maps, etc.	
Access of information	Less feedback or public involvement	
	Lack in project data management	

*Establishing confrontational contact, dominated by higher authority, fix time, feedback lack, and accessibility issues.

Table 1. Issues and concerns in existing practice of public participation.

According to Meredith et al. [20], for successful public participation, proper and adequate access to information, effective connections to decision-making process, and effective tools for getting input into a decision-making process are very essential. Public participation can become better and effective only if a large number of participants easily understand the message and give valuable feedback in short time frame.

1.3.2. Rationale on CSCW and groupware

Previous studies related to the depiction and execution of real-time collaborative mapping technologies are still in its stage of growth and development. Although in the last decade, many attempts have been made to the research of developing collaborative PPGIS, but despite of this insufficient literature is obtainable in this field [21–24].

Using proprietary software approaches, e.g., PCI geo-conference, a few GIS-based tools encompassing groupware and CSCW technologies have been originated. Some attempts have been made to originate simple map sharing applications using open map services. As a result of modern developments in geographic information technology (GIT) that assists large spatial databases, groupware technologies, and web-based GIS, several frameworks that accommodate real-time collaboration were designed and developed [25–28]. Jankowski et al. [29] developed the Spatial Group Choice, a spatial decision support framework to assist the CSCW technique.

By acquiring "argumentation philosophy," argumap (which is an asynchronous perspective for spatial participation planning, to accommodate group discussions by connecting specific notations to map features) was developed by Rinner [30]. In order to support planning and decision-making processes, SoftGIS was developed which permitted mapping local knowledge and integrating it into urban planning practices [31]. Community action geographic information system (CAGIS) is a participatory GIS approach developed by Stewart et al. [32]. Virtual emergency operations center (VEOC) framework was designed for the purpose to provide a collaborative virtual environment that allows connectivity among participants while implementing synchronous, script-driven tests and assumptions [33]. For participation in community planning, MapChat is an online geospatial tool designed at the University of Waterloo. In collaboration with planning and/or emergency management related to decision-making, Rinner [34] recognized OSGIS technologies and OSS-based Web 2.0 concepts. The aim of this study is to describe core concepts, design, and technology with an examination of allowing technologies for analyzing and designing a successful real-time map sharing mechanism. This study also narrates a framework development based on a research project that looks into connecting CSCW principles, PGIS, and open-source groupware tools with web-based GIS.

1.4. Summary of closely-related research models

Already existing PPGIS application or model assessment helped researchers to find limitations of applications' framework and current practices. Three research models which are considered relevant to the present study are discussed below. Rinner [30] introduced the

argumentation model; in his model, he introduces argumentation maps as an object-oriented model for geographically related discussions. As shown in **Figure 1**, it shows the relationships between an argumentation elements/discussion, a geographic reference object/map feature, and user-defined graphic reference objects/sketches [34].

The argumentation model object classes have reinforced many-to-many relationships. For example, an object which is geographic can associate many argumentation components, and an argumentation component can be associated by many objects that are geographical. Additionally, as shown in **Figure 1**, the objects have their self-relationships to each other of the same class. For example, geographic reference class objects have spatial relations to other objects, and argumentation component class objects can have logical relations to other objects; again, many-to-many relationships are supported [34]. The argumentation model provides an open standard-based prototype with a special focus on the use of standards to confirm interoperability. The discussion component was developed using open-source programming languages, i.e., JavaScript and Java applet. The map elements are based on an open-source Java API, i.e., GeoTools and libraries. The same kinds of models were established and acquired by Tang [35] and Hall [36] but many other technologies were used to design the prototype of research MapChat and GeoDF.

The MapChat argumentation model (see **Figure 2**) engages the same classes and objects for spatial and textual relationship in comparison with previously discussed models. A new real-time map discussion class was introduced in this model, which provided the functionality of real-time geochatting in connection with every graphic-related object. An open-source application infrastructure is provided by MapChat argumentation model. It appoints open standards in relation to the overall system specification, it uses open-source coding based on

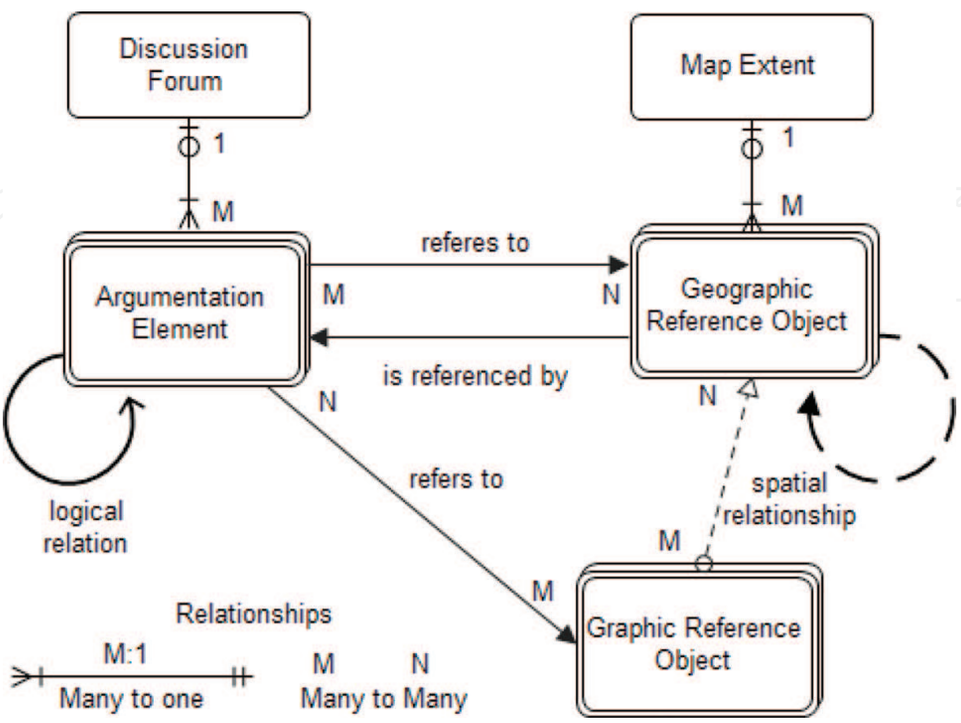

Figure 1. Modified argumentation map model. Source: [34].

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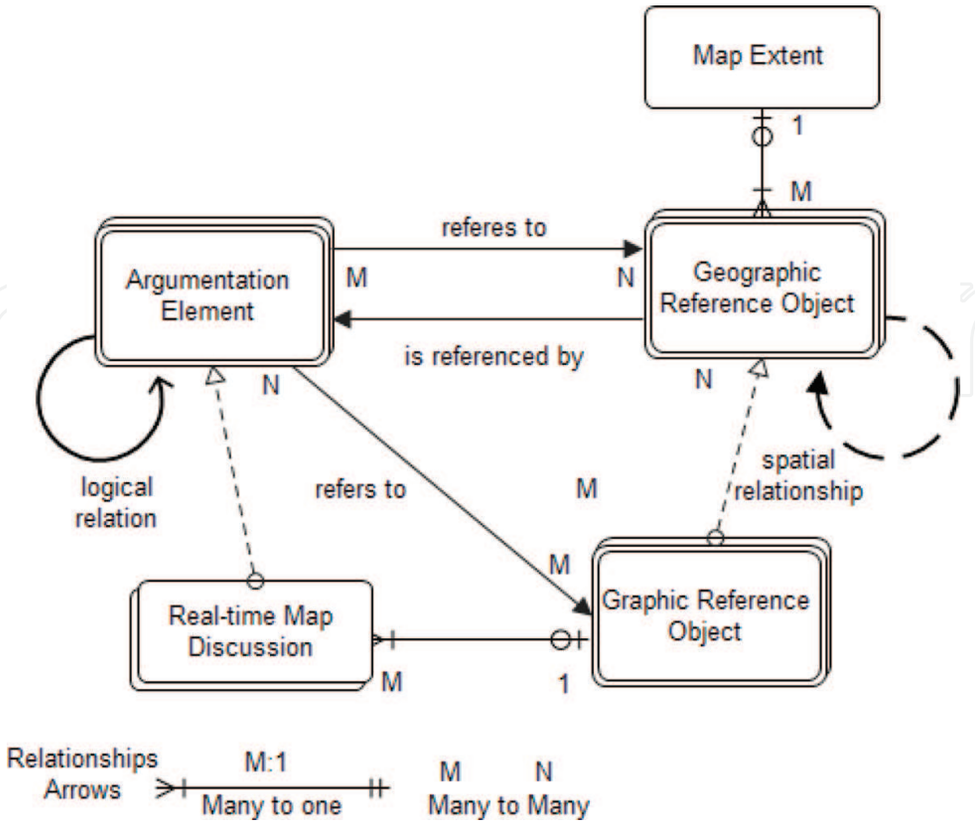

Figure 2. Modified argumentation map model for MapChat. Source: [34, 35].

PHP and JavaScript, and it uses a reliable architecture to give the installation of other tools of models [35].

These models have some sort of similarities like to introduce an open standard-based object model and to share the same map extent during discussion, making a spatial relationship with graphic reference objects and adopting an asynchronous participatory approach for map-based discussion. All three argumentation models allocate structured discussion, about different features of map and geographic-related objects, in many geographically meeting respondents to provide an approach of the asynchronous spatial data. For example, for the approach with the asynchronous spatial data sharing, it is not possible to find out an argumentation component related to the object of real world simultaneously in different respondents/members. The MapChat provides geochatting discussion functionality with real time, which cannot be implemented over other two models that used discussion threads with relation objects for geographic referencing. Unifying the chat with discussion elements gives a flexible and a powerful way of managing discussions that are geographically referenced, but participants should train themselves with this function that is amalgamation which get advantage from this reliability.

2. Design modeling of Co-PPGIS

The prosperity of developing and establishing a geospatial-enabled Co-PPGIS, for enhancing the ability of people participation in collaborative decision-making during management

workflows and municipal planning, most importantly depends on a brief understanding of firstly the ideas of community participation in management and planning which involves basic ideas of role in participation, amount of community participation, and already existing participation of community at the time of municipal development, planning, and management, and second important concern is on functional and nonfunctional requirements that are identified by existing PPGIS and that are related to research models, which are developed during municipality management to support public participatory processes. It begins with an explanation and overview of a Co-PPGIS idea, which executes the role of a real-time synchronous and asynchronous participatory approach to help the decision-makers to make decisions in assimilating the role of people at the time of a municipal planning process. Some are the information sources and withdraw for the requirements of modeling of an advance Co-PPGIS for planning and management of municipal-related projects. Although, it gives an introductory source of information that introduce an idea of advance Co-PPGIS, to understand the infrastructure of a Co-PPGIS and to find out the gaps between existing municipal planning processes and possible improvements in Co-PPGIS.

2.1. An idea of advance Co-PPGIS

An idea or concept is a plane, intention image of a specific thing, institution, or a class, and a framework is introduced as a form which gives support to the number of elements and fulfills as a packaging. Basically, a conceptual framework is a structure of interlinked ideas, which gives support of a certain phenomenon or process to build understanding. Public participation is necessary for the evolution of a country, city, and municipality planning, development, management, and decision-making, which will speed up the process of planning. During planning, development, and management of municipality in a city or state, the management of geospatial data remains a challenge. Co-PPGIS gives us a planning- and management-related spatial and nonspatial information to the decision-makers, higher authorities, and government bodies on a basis of real-time geospatial web conferencing infrastructure. In this paper, the advance Co-PPGIS has focus on municipal projects through developing a GIS-enabled virtual meeting idea. The advance Co-PPGIS framework is showed as five viewpoints, which are shortly discussed below:

Social viewpoint: The first side of social viewpoint in the Co-PPGIS is to highlight and show a name of project which will help stakeholders (see **Figure 3**) to play its role in the related project or matter. Before joining the meeting that will aid the stakeholders to find out the status of all participants submission of user profile, there are some ethics, rules, and values for community in social interaction. Their interaction level rises when the participants join the meeting or session. They exchange their ideas and views, which guide to better decision-making processes for municipal projects.

Geospatial viewpoint: This idea links with mixture of time, place, and channels of communication. To address a meeting physically, it is difficult for everyone nowadays. That is why the advanced latest technology provides participants to envision the working location. Through GIS technology, the advance prototype allows a participant to visualize an area of interest, draw or highlight, and navigate on the map any patch on the map. This is how the

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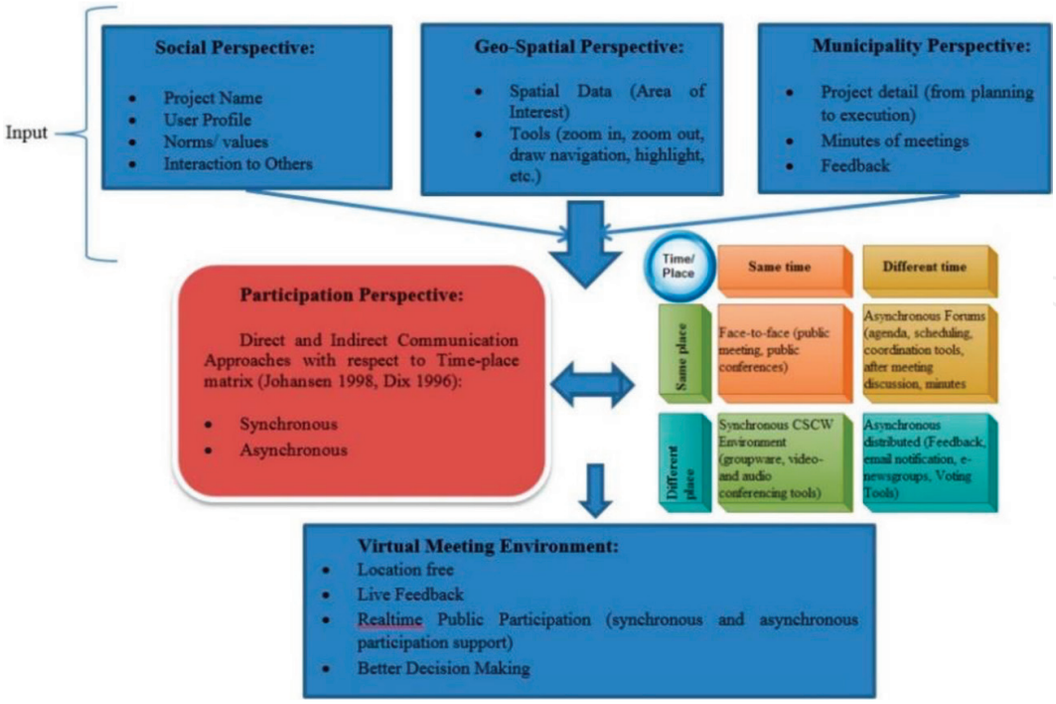

Figure 3. Conceptual framework for proposed collaborative PPGIS.

participants can seek others for discussion related to analytical issues on any point, and the provision of a small point is very essential in any project which is related to municipal.

Municipality viewpoint: In any municipal project, the idea of all information regarding a project at one place is very important. This is how one project from another project differentiates the status in the same domain. The advance collaborative PPGIS has the provision to gather supervision of data, e.g., planning info, minutes of previous meetings, drawings/maps, feedback form, notification, etc., at one place, and a participant can easily get the information at that level which they want. So, a new participant can easily reach the present level after taking information from step one. Public role is very essential in the development of projects, and its importance was not perceived in the last few decades, whereas community is now playing its essential role in making the decision-making process transparent and better.

Participation viewpoint: This crucial idea is very essential while constructing a collaborative PPGIS. It enhances participant's abilities in the municipality project standard and with their available conditions and time. In synchronous public participatory approach multiple stakeholders can view each other participation at the same time, on real-time basis, on the dashboard, white-board, and mapsharing environment. Video chats are the best example in which everyone can see and understand what the other is doing. Stakeholders have indirect communication facility through asynchronous approach in which it is not compulsory to see what the other is saying at the same time. Among stakeholders filling a feedback form is a good example of indirect communication. The advance PPGIS gives both direct and indirect communication facilities for improving the participation of stakeholders. The best example to fit the advance PPGIS participation viewpoint is the time/place matrix

which is categorized according to the spatial and temporal dimensions [37, 38] and starts from the same time (synchronous) and same place (co-located), different time (asynchronous) and same place, different time and different place (distributed), and same time and different place.

Virtual meeting environment: With the passage of time, technology has become more advance and friendly. The advance Co-PPGIS has a solution in which a participant can easily participate through the electronic meeting facility without appearing physically in the meeting and share his views with relation to project. Participants can do video chat and can drop a message for a specific participant without any restriction. This is how decision-makers can easily involve in any project, which is being developed for a municipality for its effectiveness and efficiency, which will ultimately lead to better decision-making process. In developing countries resources are minimum and need is maximum like Pakistan and India. There is massive need for developing such thing for public, which gives all these facilities which are mentioned above to give comfort to decision-makers.

Shortly Co-PPGIS environment is an online meeting procedure for supporting participant's collaborations on geographical information like mapping and imageries and collecting and

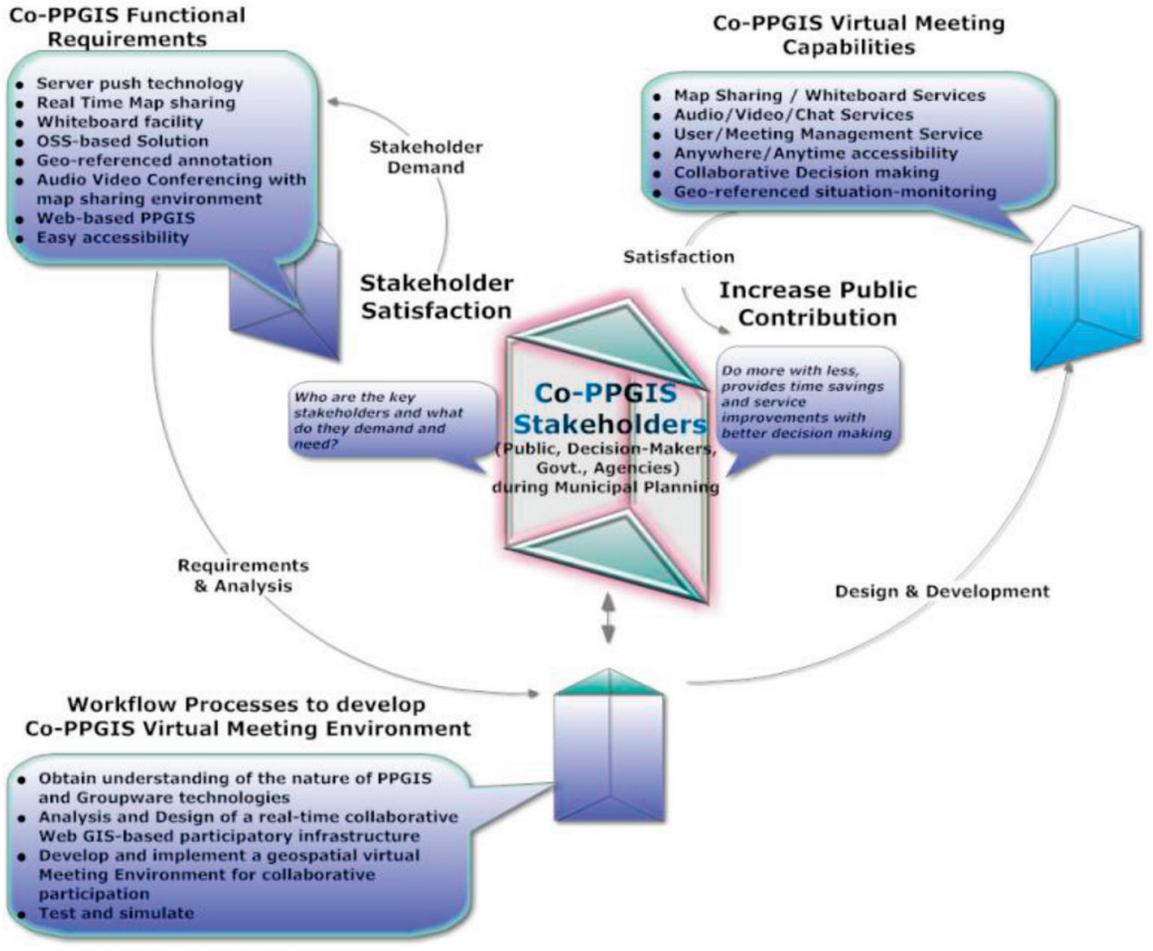

Figure 4. Co-PPGIS workflow processes and service abilities.

sharing data during processes of management. **Figure 4** shows Co-PPGIS virtual meeting workflow processes and service abilities to describe situations when its functional capabilities are useful.

This kind of environment allows combination of geospatial data from other sources from web services and collaborators input through geo-referenced comments. It involves components such as audio/video conferencing, map sharing, geo-referenced textual, real-time chatting and graphical annotation, and user or session management.

2.2. Exploring gaps in existing municipal planning practices and possible improvements using Co-PPGIS

Exploring and contrasting of existing PPGIS application's performance are essential or helpful in recognizing the functionality gaps between those collaborative PPGIS applications which organized crucial basis for Co-PPGIS requirement analysis and architectural design. **Figure 5** depicts the research gaps in current or existing communication mediums or participation practices found during the literature review and recommended how the Co-PPGIS contributes to the existing practice in order to increase public participation in municipality planning and development projects. It also explains how the approaches in relation to the proposed/enhanced infrastructure of Co-PPGIS will organize, improve, stimulate, accommodate, and contribute to the existing public participation practices.

The issues and improvements of these issues through Co-PPGIS are explained in this section. For instance, (1) through or by using Co-PPGIS meeting environment, the issue of inadequate communication, generated due to fixed-time meeting schedules, accessibility issues, lengthy

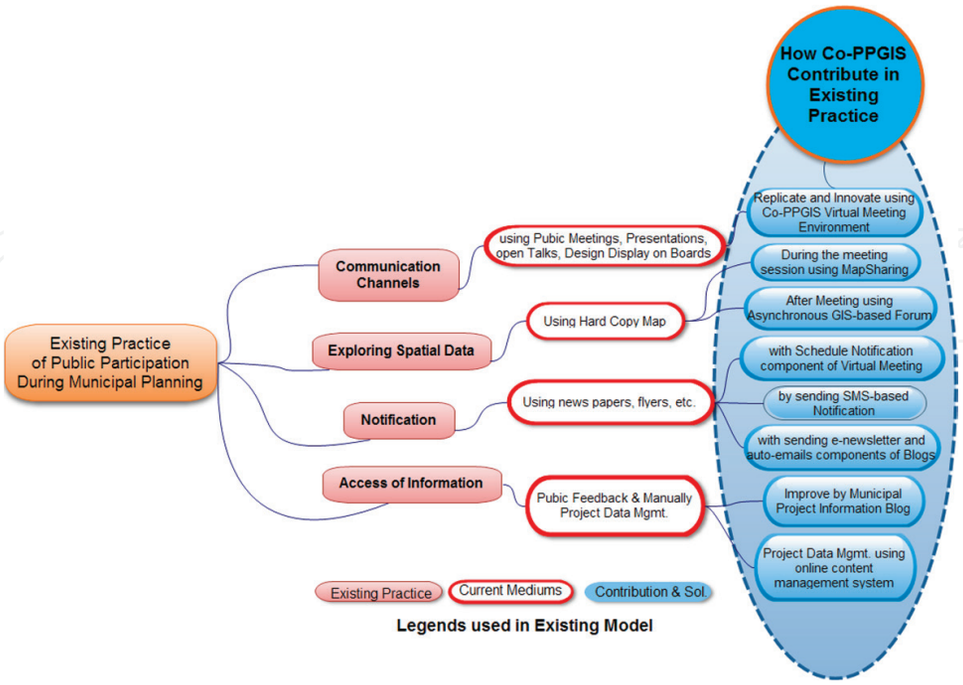

Figure 5. Identifying relation between existing participation practices and the suggested Co-PPGIS.

presentations, and open talks with authorities, can be accompanied because Co-PPGIS supports accesses anywhere/anytime/to anyone with real-time participation support. (2) Through a spatial component of GIS-based platform or through real-time map sharing cooperative component of the Co-PPGIS, the issue of inadequate way of investigating spatial data is the use of hard copy maps in the meeting sessions because CPPGIS increases the degree of public participation along with spatial data investigation during essential meeting sessions. (3) Through meeting scheduling/notifying and/or by the e-newsletter components of Co-PPGIS Blog, the issue of inadequate process of sending notification related to existing municipal development projects can be self-regulating/self-operating. (4) Information access associated to a municipality project's level data can facilitate through project information blog which exhibits the existing or future municipal project's notice detail, minutes of the meeting, presentation, document, location, and all valuable information. (5) Through Co-PPGIS, the absence of support to quick decision-making can be encouraged because Co-PPGIS upgrades or improves public participation or input as well as assists scattered decision-makers to work coincidentally on a real-time basis to conclude the decision in timely manners, which eventually diminish the time span of planning and probability of failure.

The upcoming sections demonstrate prototypes' execution of the proposed framework to assist its real-time synchronous participatory procedures that exhibit the innovations to be expected when trying to perceive the concepts established in this research.

3. GeoMeeting prototype

In order to aid the Co-PPGIS synchronous participation procedure, which is originally developed and designed to resolve the issues associated with the municipality planning and management, GeoMeeting prototype is executed as a proof of concept. GeoMeeting prototype was developed and designed for effective geo-cooperation among the national society, government, and local and international NGOs. GeoMeeting prototype is basically a web-based geospatially enabled conferencing system that accommodates synchronous and real-time amalgamation of data from different sources through web map services, like APIs, and supports the amalgamation of local knowledge demonstration by meeting participants. It also supports real-time map sharing, geo-referenced map notations, geochatting, and user and meeting management for accommodating conversations among multiple users that are geographically located at different places. GeoMeeting is developed from scratch, amalgamating the technologies of open layer and flex technologies, having associated step-by-step development processes (that means limitations discovered during the first version of prototype are enhanced in the next version of the development).

GeoMeeting system which is geo-enabled comprises the following capabilities:

- All the multiple users and participants in a GeoMeeting can sight the same geo-referenced map simultaneously; that's why it is called geo-enabled GeoMeeting system.

- In order to undertake synchronous conferencing, the GeoMeeting server application employs a push technology procedure like real-time instantaneous messaging which is a typical example of push services.
- GeoMeeting provides real-time map sharing among multiusers or participants.
- GeoMeeting is provided by geo-referenced pointer with a purpose of pointing at the shared view of map.
- With the aid of whiteboard facility, multiple users or participants can produce geometry-based incidents.
- GeoMeeting provides the opportunity of proper handling of maps (like modifying layers, map scale, and its position) to participants and users. It is very easy to rotate or change the map view among different base map layers like street map, satellite, hybrid, and terrain in GeoMeeting prototype.
- In GeoMeeting participants or multiple users can easily produce and share geo-referenced notations.
- In the construction and installation of GeoMeeting prototype, a web-based client-server architecture is very easy; we just need to plug and play.
- Through the use of any browser like Chrome, Opera, Internet Explorer, and Firefox, GeoMeeting prototype provides the opportunity of the easy accessibility of the main interface of a prototype to the users.

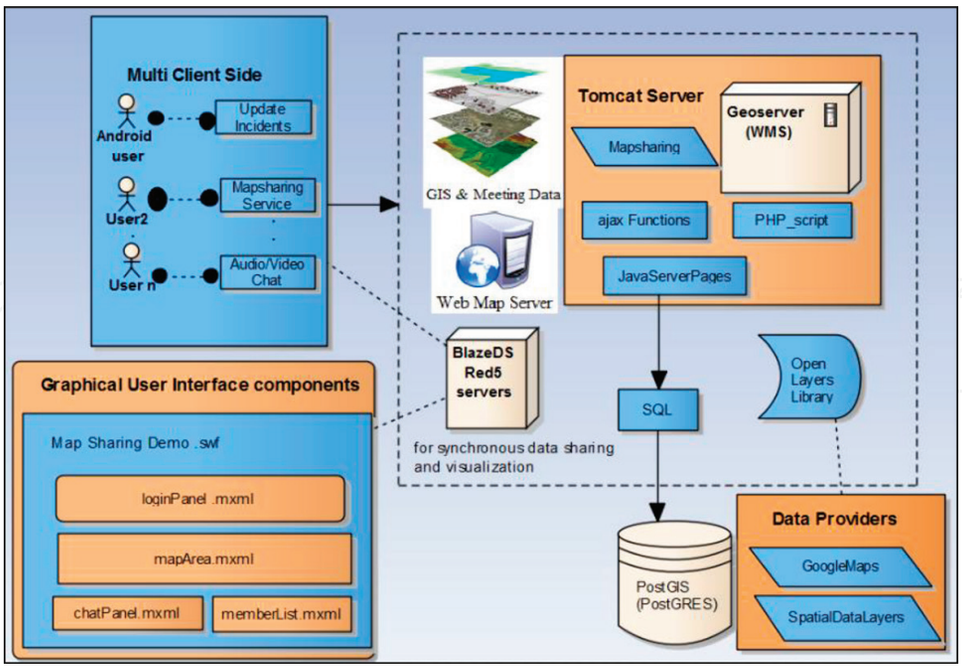

Figure 6. Conceptual architecture of the GeoMeeting system.

- Online map sharing application is depicted using open-source technologies, APIs, and programming languages like Flex SDK, MXML, Adobe BlazeDS, JavaScript, ActionScript, OpenLayers API, etc.
- GeoMeeting application is considered extremely useful during collaborating decision-aimed events such as emergency response, disaster management, and urban planning activities because GeoMeeting is a live conference technology.

GeoMeeting has myriad of capabilities, but its operational status is still in its progressive stage. **Figure 6** demonstrates a conceptual architecture of the GeoMeeting system.

The upcoming section discussions are based on the execution of different versions associated with the GeoMeeting prototype development.

4. Concluding remarks

Co-PPGIS, a web-based geospatially enabled conferencing system, assists a real-time participation to facilitate and improve public participation for collaborative decision-making which will bring fundamentally more understandability in any system. This web system provides real-time amalgamation of data from different sources through web map services, such as APIs, and supports the amalgamation of local knowledge expressed by meeting participants. In order to aid the Co-PPGIS synchronous participation procedure, which is originally developed and designed to resolve the issues associated with the municipality planning and management, GeoMeeting prototype is implemented as a proof of concept. GeoMeeting prototype framework facilitates any sort of e-governance, management, and emergency scenarios (e.g., municipal planning, forest management, urban sprawl, state lands, crime mapping, disaster response, etc.) related to collaborative decision-making and provides an effective, valid, and see-through system in which all the discussion and recommendations between authorities and participants are conserved in the database and can be viewed anytime to know the irresponsibility of even a common person to some authority handling the entire situation. The GeoMeeting is an evolution of map sharing component build previously based on collaborative PPGIS framework, which accommodates effective and better decision-making through its innovative map sharing component technology.

The infrastructure of GeoMeeting was established on several component-based services such as login management, floor control, map sharing, Android, feature-based chat, feature popup service, geometry and multimedia sharing feature services, bookmark, and live video services. Registered users can have direct access to GeoMeeting through login authentication. The component also includes chat facility, drawing specific location (point, line, and polygon/area), base layer switcher for better understanding of map, and search field for any area of interest, synchronously. These component-based services make it effective and efficient platform for information/data sharing. Previously, teleconferencing was the only medium used during emergency management planning, but the drawback for teleconferencing was the absence of any geo-collaborative console, i.e., map sharing. GeoMeeting provides real-time geo-collaboration, which improves accuracy and efficiency as well as saves cost and time

of the emergency management organization. Consequently, this Co-PPGIS framework-based GeoMeeting provides an interactive interface to have geo-enabled collaborative participatory discussion platform among decision-making authorities and common people.

Author details

Muhammad Atif Butt[1,2]*, Syed Amer Mahmood[1], Javed Sami[1], Jahanzeb Qureshi[1], Muhammad Kashif Nazir[1] and Amer Masood[1]

*Address all correspondence to: m2butt@ryerson.ca

1 Department of Space Science, University of the Punjab, Pakistan

2 Department of Civil Engineering, Ryerson University, Toronto, Ontario, Canada

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