Chapter 2

Architectural Design and Prototyping of Co-PPGIS: A Groupware-Based Online Synchronous Collaborative PPGIS to Support Municipality Development and Planning Management Workflows

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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 chapter 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 as map sharing, real-time chat, video conferencing, 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. However, now, Geographical Information System and PPGIS are not prototyped to assist multi-users associations but 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) were proposed as information technology to provide understanding about spatial complications and provide computer-based spatial decision-making [2].

Multi-user collaboration is playing its role in many works involving stakeholders from different departments and organizations, in which map making sometimes play a main role for giving visual information for the support to decision-making [3]. Web technology is rapidly expanding range and has made it possible for 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 have 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 that 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 [10]; although, little work has been done on developing and designing such Open Source Software (OSS) which is based on online map sharing tools which supports 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. Multi-user synchronous discussions and communications among the people and between the community and stakeholders sometime improve the understanding that show an effective feedback and magnify decision-making [10–14]. This chapter 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 this research prototype elements based on this kind of model is still in development procedure and in its starting stage in the house applicable testing.

1.2. Study objectives

The study aims to develop a real-time map sharing mechanism, 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 to assure that: (1) 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; (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 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.

3. To develop and execute a system's prototype (i.e., GeoMeeting) based on the Co-PPGIS model and Web GIS-based framework which encompasses a GIS-based forum, mapping APIs-based spatial component, a notification/feedback component, sub-workflows of information resource providers, and collaborative real-time Web Map sharing Infrastructure that accommodate the stakeholders to share their multiple ideas in real-time scenarios without leaving their place of residence or workspace.

This research primarily encompasses of 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 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 are one of the traditional methods of public participation, are 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 conceptualize a map and accommodate 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, planning process 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 enquires 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 Power Point or point boards which is still considers one of the most commonly used participatory approach [19]. In the 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 United States and Canada, local governments and many municipalities necessitate a level of participation in their decision-making processes.

Table 1 reveals issues and concerns which 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. (2006) also disclosed several main issues regarding to 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

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 projects 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.

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.

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 became better and effective only if a large number of participants easily understand the message and give valuable feedback in a 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 is 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]. The rapid developments in technologies like in GIS, OSGIS, GIT, CSCW, and groupware filed will have a notable impact on the transfer and/or integrate those technologies into collaborative contemporary GIS. Rinner [25] and Li et al. [13] recognize the need to support such technologies that provide a limited way of investigating spatial data or map information collaboratively by inaugurating asynchronous-based geo-referenced mapping architecture.

Baecker [26] defined groupware as information technology used to accommodate people to work together more effectively and efficiently. With the help of the CSCW application or groupware technologies, people in remote places can easily and effectively interact with each other by sharing the documents and files through voice, data, and video links [27, 28]. 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 assist large spatial databases, groupware technologies and Web-based GIS, several frameworks that accommodate real-time collaboration were designed and developed [29–32]. Jankowski et al. [33] developed Spatial Group Choice, a spatial decision support framework, to assist the CSCW technique. Churcher and Churcher [34] proposed and developed Group ARC which offers a tool to geographically dispersed people to collaboratively view and explain map/spatial data. Pang and Fernandez [35] designed and developed Real-time Environment Information Network and Analysis System (REINAS) which encompasses functionalities that are helpful in the analysis of geospatial data. In order to support decision-making in Trane China, Trane China SDSS (TCSDSS) was designed by Xiang (2003) by adopting the unified software-development process.

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 [25]. In order to support planning and decision-making processes, SoftGIS was developed which permitted mapping local knowledge and integrating it into urban planning practices [36]. Community Action Geographic Information System (CAGIS), a participatory GIS approach developed by Stewart et al. [37]. 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 [38]. For amplifying collaborative decision-making among geographically distributed people, synchronous collaborative 3D GIS was designed by Chang [6] to assist synchronous collaboration. For participation in community planning, map chat is an online geospatial tool designed at the University of Waterloo. Collaboration in planning and/or emergency management related to decision-making, Rinner [39] recognized OSGIS technologies and OSS-based Web 2.0 concepts (that encompasses n-tiers application client-server architecture, Web mapping tools, Participatory Geographic Information System (PGIS), Web Mapping Services, 3-D GIS technology, CSCW, and Web-based groupware to accommodate consideration in spatial decision-making) that have played an essential role in this regard. 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' applications or models 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 [25] 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 [39].

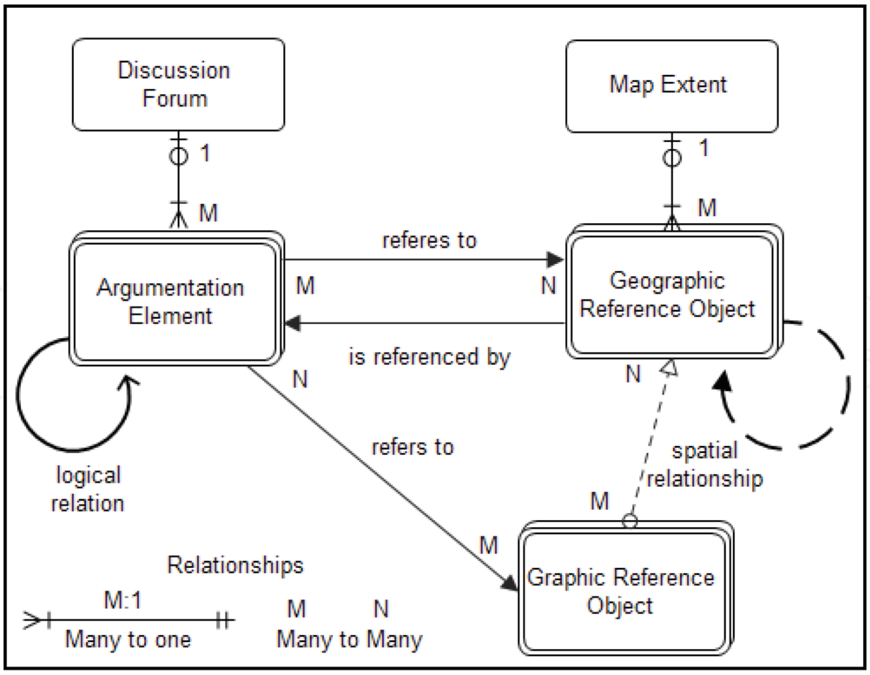

Figure 1. Modified argumentation map model (source: Rinner [39]).

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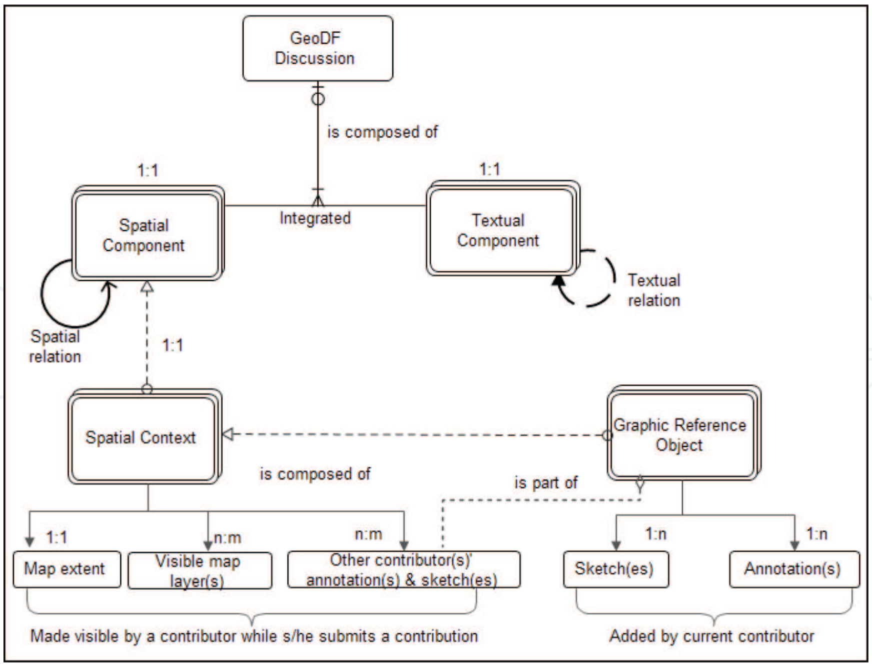

Figure 2. Modified argumentation map model for GeoDF (source: Tang [40]).

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 object, and argumentation components, class objects can have logical relations to other objects; again, many-to-many relationships are supported [39]. 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., Geo Tools and libraries. Same kinds of models were established and acquired by Tang and Hall (2006) and Leahy (2006), but many other technologies were used to design the prototype of research Map Chat and GeoDF. Tang GeoDF model installed an open source-based PHP built in board with commercial-based ESRI Arci MS/spatial server to develop GeoDF prototype. **Figure 2** shows several elements of GeoDF model.

Every conversation is comprised of two main components, i.e., the textual component that is basically related to a respondent's understanding about the shown as text and spatial components that is actually a part of spatial element and is a together term used is geographic features, map extent, location, and spatial relationships embedded in GeoDF discussion threads, which are the thoughts, views, or feedback submitted by a participant via the GeoDF. In other words, the spatial context is primarily comprised of graphic reference objects, i.e., annotation, sketch, and other respondent's annotations and sketches together

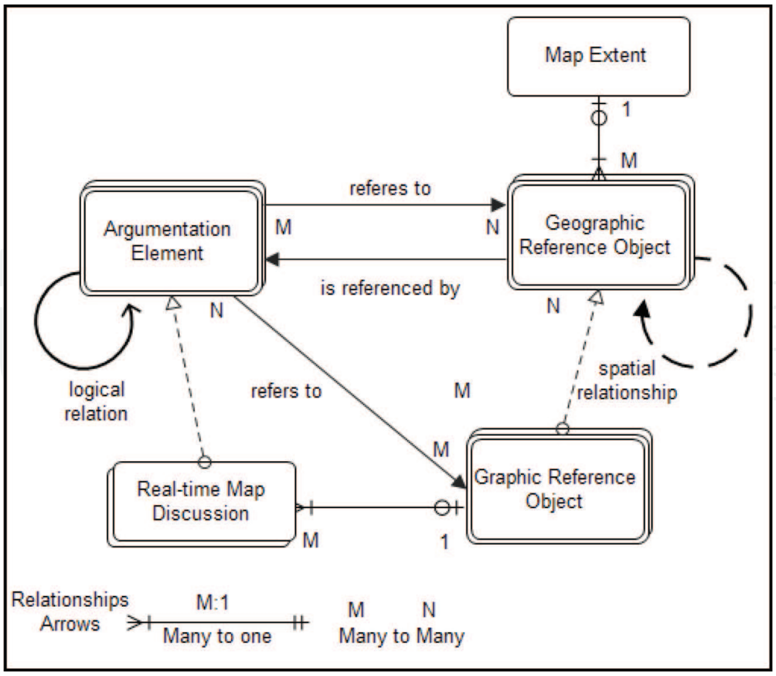

Figure 3. Modified argumentation map model for map chat (source: Hall and Leahy [41]; Rinner [39]).

with other two spatial components, visible map layer, namely the map extent [40]. The Map Chat argumentation model (see **Figure 3**) 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 geo-chatting in connection with every graphic related object. An open source application infrastructure is provided by Map Chat argumentation model. It appoints open standards in relation of the overall system specification and it uses open source coding in PHP and JavaScript based, and it uses a reliable architecture to give the installation of other tools of models [41].

These models have some sort of similarities like to introduce an open standard-based object model, to share a 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, 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 Map Chat provides geo-chatting 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 gets advantage from this reliability.

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2. Design modeling of Co-PPGIS

The prosperity of developing and establish a Geospatial enabled Co-PPGIS, for enhancing the ability of people participation in collaborative decision-making during management workflows and municipal planning, most importantly it depends on a brief understanding of firstly the ideas of community participation in management and planning which involves basics 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 non-functional requirements, that are identified by existing PPGIS and that is 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 to assimilate people role 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 fulfill as a package. 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 non-spatial information to the decision makers, higher authorities, and government bodies on a basis of real-time basis geospatial Web conferencing infrastructure. In this chapter, 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 4**) 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.

Geo-spatial 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 envision the working location. Through GIS

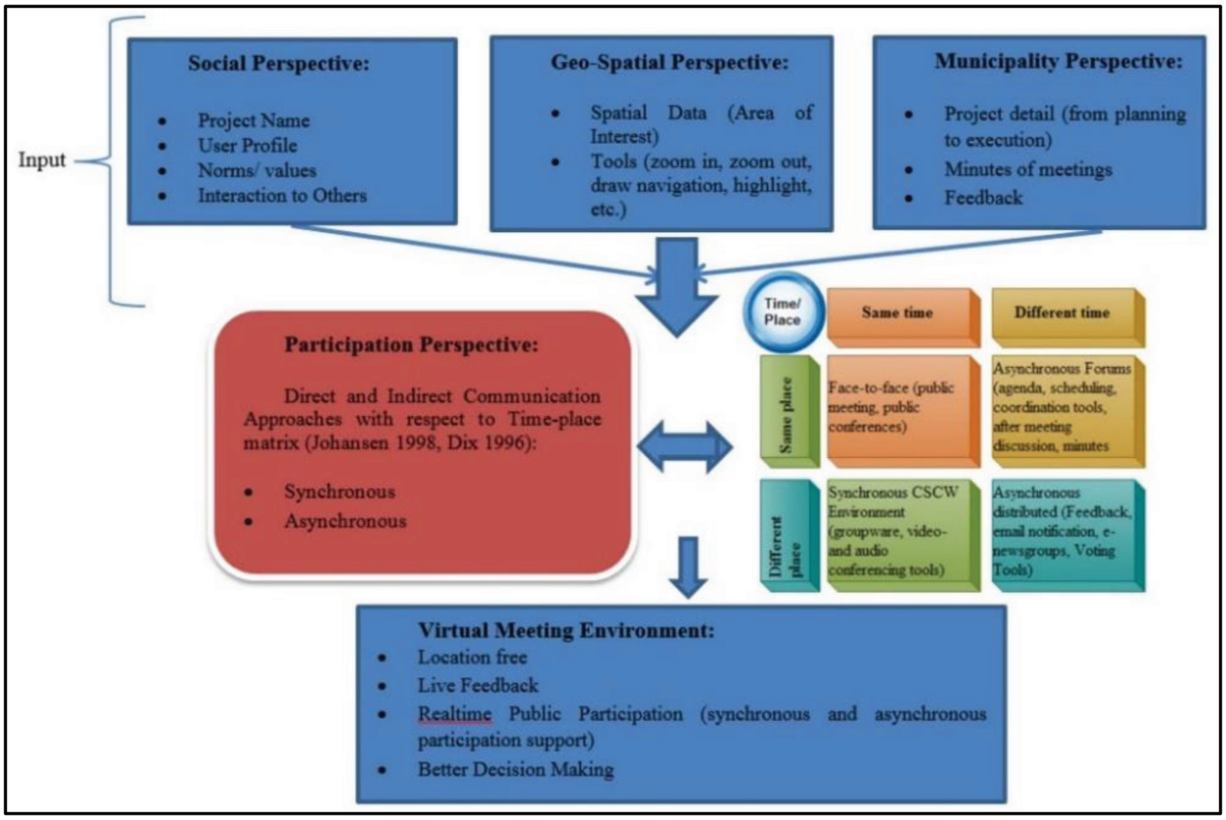

Figure 4. Conceptual framework for proposed collaborative PPGIS.

technology, the advance prototype allows a participant to visualize an area of interest, draw or highlight, navigate on the map, and patch on the map. This is how the 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 and supervise the 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 for 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. Through synchronous approach, in which multiple people can see what the other people are doing at the same time without wasting, the second group of participants can share their point of views using drawing tools, mapping. Video chats are the best example of in which everyone can see and understand what other is doing. Stakeholders

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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 [42, 43] starts from 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 a 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 sharing data during processes of management. **Figure 5** shows Co-PPGIS virtual meeting workflow processes, service abilities, and to describe situations when its functional capabilities are useful.

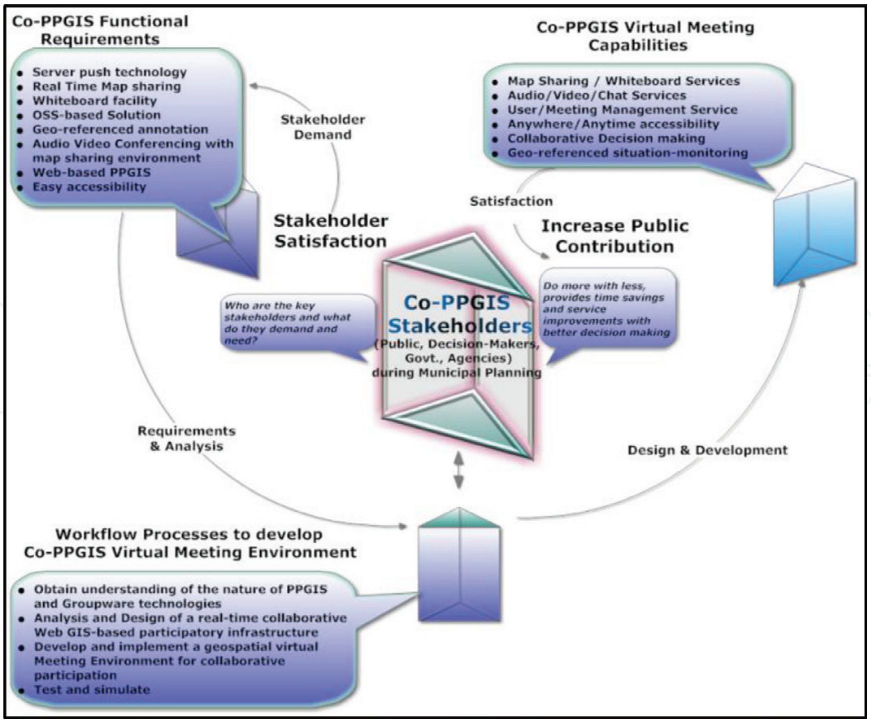

Figure 5. Co-PPGIS workflow processes and service abilities.

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. Understanding a Co-PPGIS infrastructure

Co-PPGIS is basically a GIS-enabled collaborative and multi-function, essential meeting participatory infrastructure, which combines different information technology tools to accommodate participation and cooperation activities before public meetings (i.e., the major activities before public meetings is focused on information access, communication, and cooperation of stakeholders), during public meetings (i.e., real-time access to the meetings and their demonstration become paramount tasks), and after public meetings (the focus alters to the demonstration of syntheses of public participation, access to decisions, and receiving of feedbacks). As from above discussion, it is concluded that Co-PPGIS primarily centers on public meetings engaged during the municipal planning and development-related activities (**Figure 6**).

In order to properly and easily understand Co-PPGIS system completely, Co-PPGIS may be categorized as and/or mainly composed of two major application infrastructures. In other words, we can say that recommended Co-PPGIS is basically an amalgamation of two mechanisms of participation, cooperation, and communication between members, i.e., Co-PPGIS asynchronous and Co-PPGIS synchronous. In Co-PPGIS asynchronous participatory environment, Web-based GIS geo-referenced conversation platform and/or GIS Blog techniques are used to accommodate public input and discussion. In Co-PPGIS synchronous participatory map sharing environment, synchronous collaborative GIS processes are executed by applying computer supported cooperative work (CSCW) or groupware application principles. By this, participants can easily share comments, ideas, or suggestions after investigating spatial data by using digital multimedia tools and technologies (**Figure 7**).

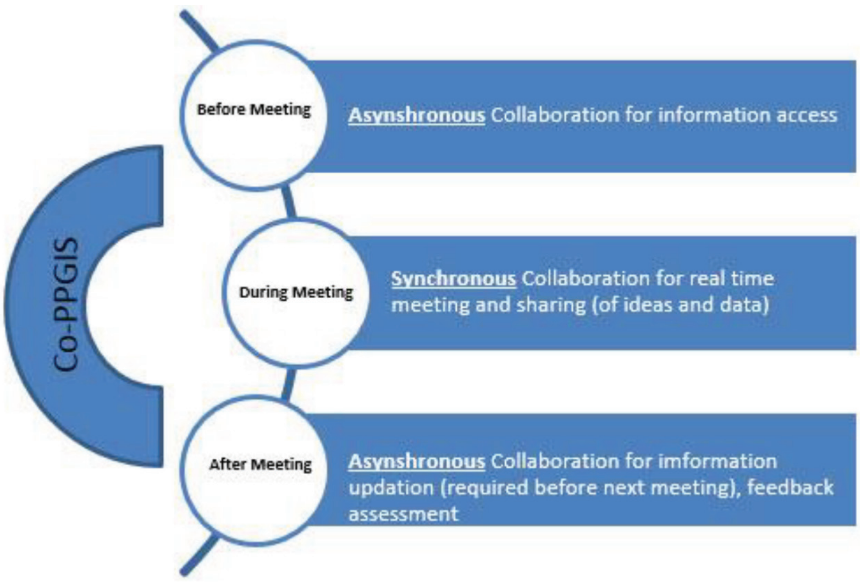

Figure 6. Public meeting scenario at three stages/levels of interaction.

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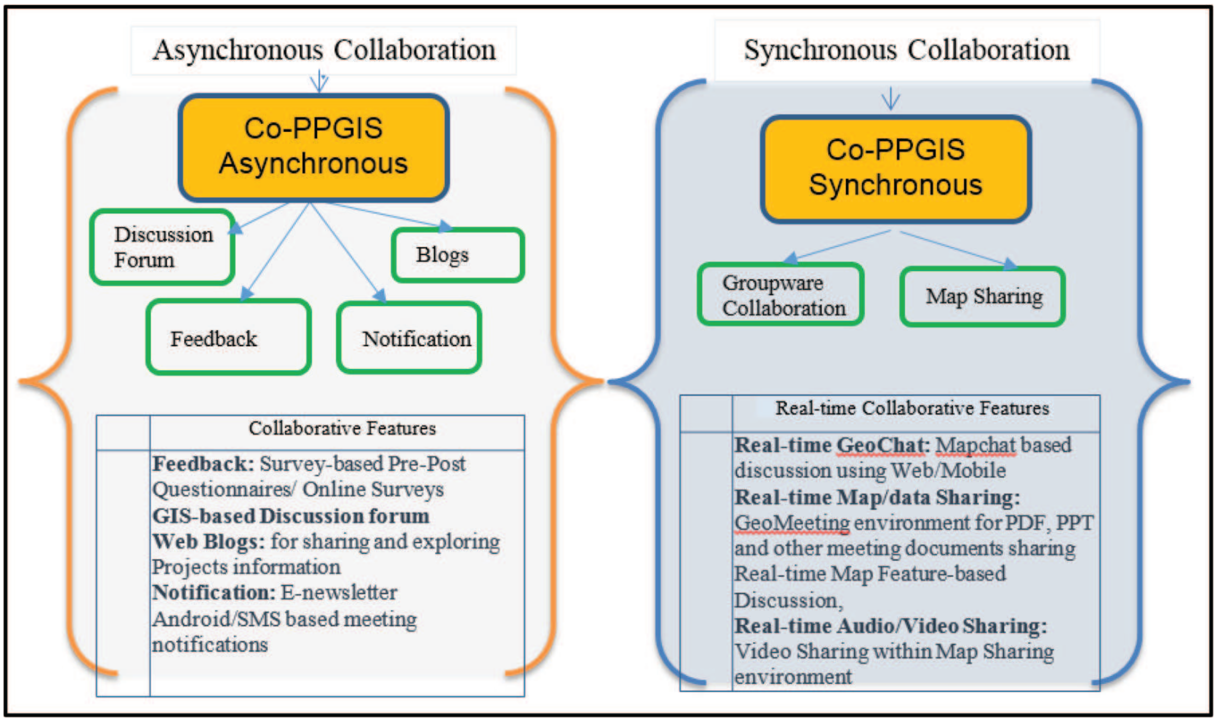

Figure 7. Co-PPGIS virtual meeting components for concept of planning and management.

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

Exploring and contrasting of existing PPGIS application's performance is 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 8** 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.

Issues and the 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 presentations, and open talks with authorities can be accompanied because Co-PPGIS supports anywhere/anytime/anyone accesses 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, i.e., using hard copy maps in the meeting sessions because Co-PPGIS increase 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

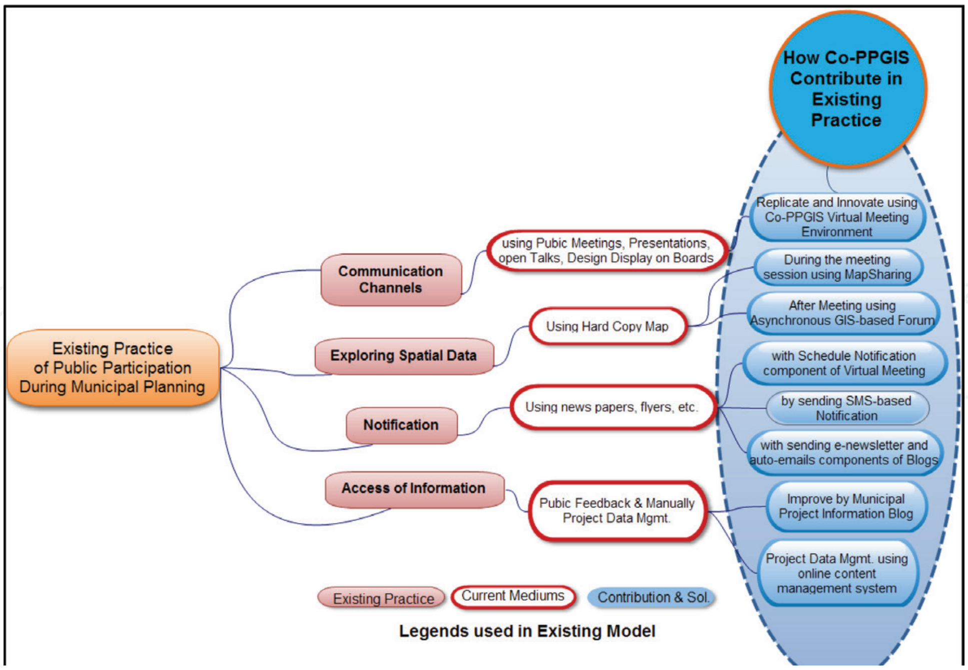

Figure 8. Identifying relation between existing participation practices and the suggested Co-PPGIS.

development projects can be self-regulating/self-operating. (4) Information's access associated to a municipality project's level data can facilitate through project information blog which exhibit 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 upgrade or improve public participation or input as well as assist 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 service-aligned architecture

The way in to GeoMeeting services can be through login authentication. With direct way in, the user can log in by just choosing a screen name; on the other hand, in login mechanism, user only have to register the user's login for sharing the data and services (see **Figure 9**) provided by Co-PPGIS.

Some of the components-based services provided in the GeoMeeting are explained as follows:

Service for login management: HTML and Web pages are developed to user profile database. HTML used The PHP form very long to sending variables such as name and email address, etc., and receiving results. By using Structured Query Language (SQL), PHP scripts process

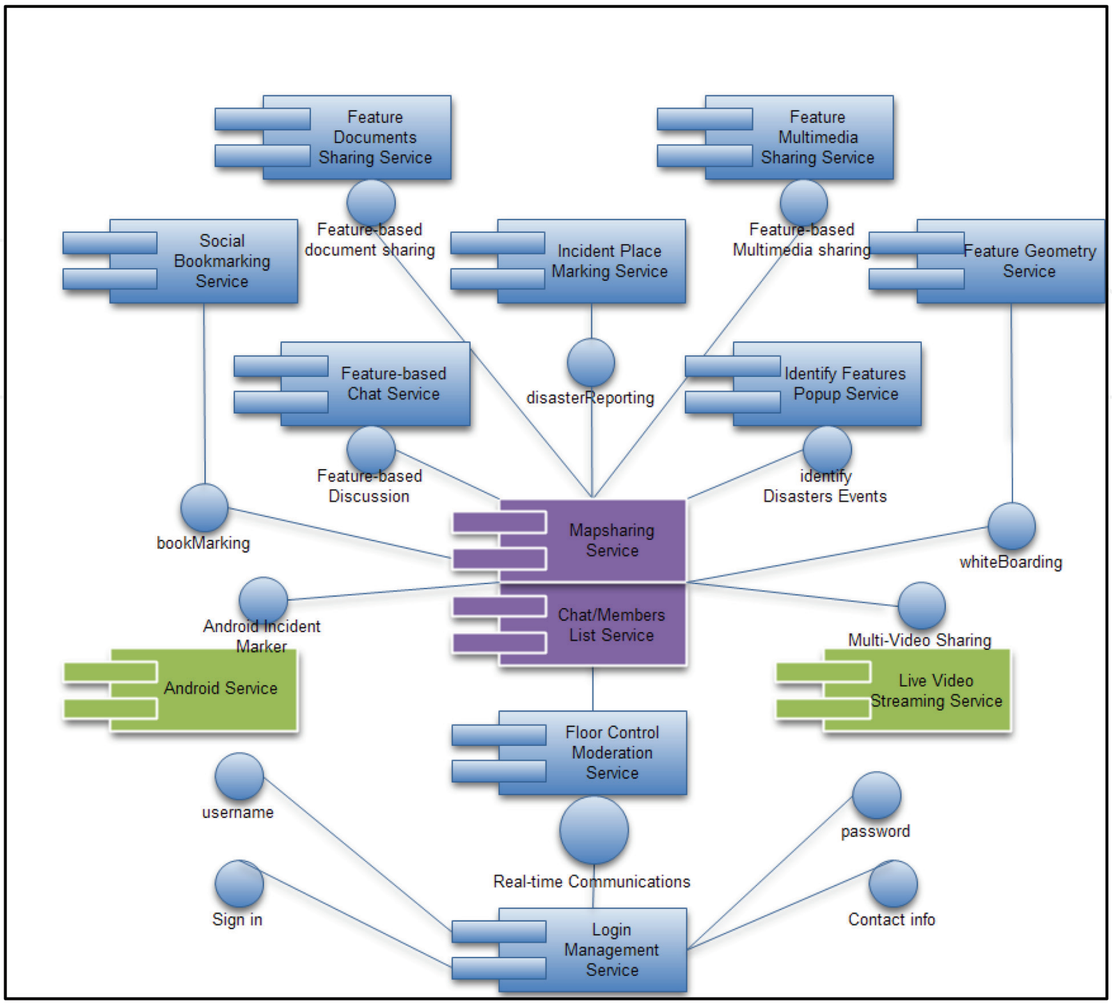

Figure 9. GeoMeeting components-based services.

these input variables and send it to the database for verification. And then, user is moved toward GeoMeeting interface after this process.

Service for floor control: Floor controller is the process which is requested when administrator flicks main toolbars for the purpose to elude the distraction from other attendees during the session of GeoMeeting. The purpose of working behind is that a message is sent through flex service to Blazeds server and shared with other attendees. Once, the IDs of tool bar are collected and stored, i.e., map panning, use of toolbars and scrolling will be flick, and if any participant wants to discuss on the map interface, that user may ask from the moderator by sending a request using JavaScript.

Service for member list: The flex controller saves the user name and sends it into a user list panel which is constructed using flex-based server scripts. When the user signed in or logged in, the widget is shared in html div with other users using Blazeds.

Chat service: In flex and PHP languages, chat object is developed. In flex server-side scripts, when a user types in the chat window, it delivers and shares among other users using Blazeds real-time messaging service.

Service of map sharing: Map sharing idea is designed and got using JavaScript programming languages and Flex. During map sharing, it provides environment, when a user go for the zoom or extent of the map, the value of the extent and zoom is recorded through JavaScript function and send to flex server (Blazeds) which react to all users for map synchronization. In outcome, every person or user can share the same map area on screen.

Android service: User collects and updates the incidence rate using a Java-based application. Information related to textual and multimedia data are changed to xml format and recorded in the database through XML writer and Java Server pages (JSP). XML parser identifies the xml and data are showed on the map through JavaScript.

Feature-based chat service: The feature-based chat element operation and workflow is managed in JQuery and JSP. Popup window process controller gets the information by the user and sends it to the JSP using JQuery. After that, JSP gives the information to the database by an SQL for record and receiving of the message posted. Chat messages are real-time shared in different attendees during meeting using Blazeds Server.

Identify feature popup service: Identify feature popup is constructed to find out the selected elements properties. On elements selection, a JavaScript uses for finding out and showing all feature's elements information inside the popup window through HTML.

Geometry feature service: Geometry feature service is noted in JavaScript languages and JSP. When features are drawn, for example point, line, polygon, circle, annotation, and hexagon on a map and geometry object of the feature are inherited using open layer's JavaScript library. If this library is saved in directory on the Web-server than it can be studied by client browsers, apart from that it can have access from online URL. On the server side, JSP can then find out by reading and parse by a text and then save the geometry into a database of PostGIS. In the return, JSP reads outcomes, for example, attributional information and geometry from database through SQL and xml converted by JavaScript for showing and parsing map shapes.

Another way of developing basic geometry elements in GeoMeeting is through WMS, which is served through GeoServer. The stored characteristics and geometry are declare to GeoServer and can way in or read by browsers through open layer functions and JavaScript. When a new element is developed on a map, JavaScript function take the ID of each element and deliver to the Blazeds, elements are shared to all the other users those are on board.

Feature multimedia sharing service: Feature multimedia sharing service is created to build connection multimedia objects for example images, audio and video files against each geometry shape or incident for the purpose to share rich information among managers. All multimedia files are record on the Web-server; whereas, element information with multimedia objects get through JSP. Multimedia is classified based on type and each category is showed in different GeoEXT panels.

Bookmark service: Bookmark service is constructed to save the extension of the map and important discussions made by different users. When a user clicks on the bookmark, the extent and zoom of the map are saved into the database through JSP Get function.

Live video service: With the live video-based interactive communication service, any person can share audio and/or video while demonstrating his/her ideas on the map. GeoMeeting video service is developed using Flex, Action Script, and JAVA programming languages. The meeting client accesses the RTMP protocol of RED5 streaming video server, for sharing the video among participants. GeoEXT-based video popup sports a very simple user interface so that everyone can focus on the Geo-enabled meetings—not on technology. The participants do not have to install anything (even to broadcast audio), in brief; a single click starts video conferencing among multi-participants.

4. 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 National Society, government, 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, geo-chatting, 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 mean limitations discovered during the first version of prototype is enhanced in the next version of the development).

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

- As all the multiple users and participants in a GeoMeeting can sight the same geo-referenced map simultaneously that is why it is called geo-enabled GeoMeeting system.
- In order to undertake synchronous conferencing, the GeoMeeting server application employ a push technology procedure like real-time instantaneous messaging are typical examples of push services.
- GeoMeeting provides Real-Time Map sharing among multi-users 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 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.

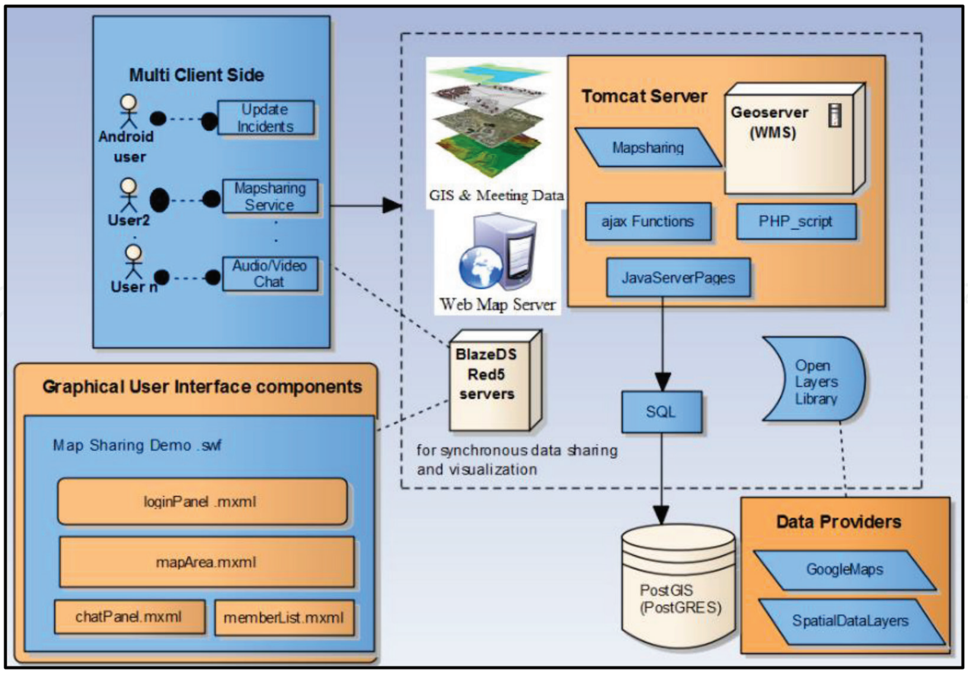

Figure 10. Conceptual architecture of the GeoMeeting system.

- 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, or Firefox, GeoMeeting prototype provides the opportunity of easy accessibility of the main interface of a prototype to the users.
- Online map sharing application is depicted using open source technologies, APIs and programming languages like Flex SDK, MXML, Adobe blaze DS, Java Script, Action Script, and open layer 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 10** demonstrates a conceptual architecture of the GeoMeeting system.

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

5. Walkthrough of GeoMeeting prototypes

This section explains functionality requirements and enabling technologies of three GeoMeeting prototype's design.

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5.1. GeoMeetingV1

5.1.1. Key features

Participants may visit the log-on page for GeoMeeting using a standard Web browser such as Mozilla Firefox 13+. Once the log-on page is displayed, the person can enter a user name and connect the GeoMeeting environment. After the meeting session is entrenched, the GeoMeeting elements will charge its default interface as shown in **Figure 11**.

Depending on your connection speed, the loading of Web services from different sources may take only a few minutes or sometimes take few seconds. The GeoMeeting component provides the following key functions: *Caption A* illustrates two pointers. Black pointer will activate the geo-referenced pointer on the GeoMeeting component that has a means of "gesturing" at the map to other participants and helps in highlighting an study area issue which can be seen by all participants on a real-time basis, whereas the white pointer will deactivate the pointer on the GeoMeeting component to other participants who can be useful for single user/moderator work. All participants map will relocate as of the moderator, and participants can have discussions over there. *Caption B* illustrates a search toolbar. Search option provides the way to find a specific place of interest. The textual/graphical comments may be included at a see-through map layer and act as a shared whiteboard. The features can be in the configuration of points, lines, and polygons. These configurations are geo-referenced which means that they will be scaled as the map display is zoomed and extent which show outcomes in no misrepresentation of the configuration. The geo-referencing toolbar is constructed for the purpose to show the real-time supportive geo-referenced based configuration on map. The annotation tools are

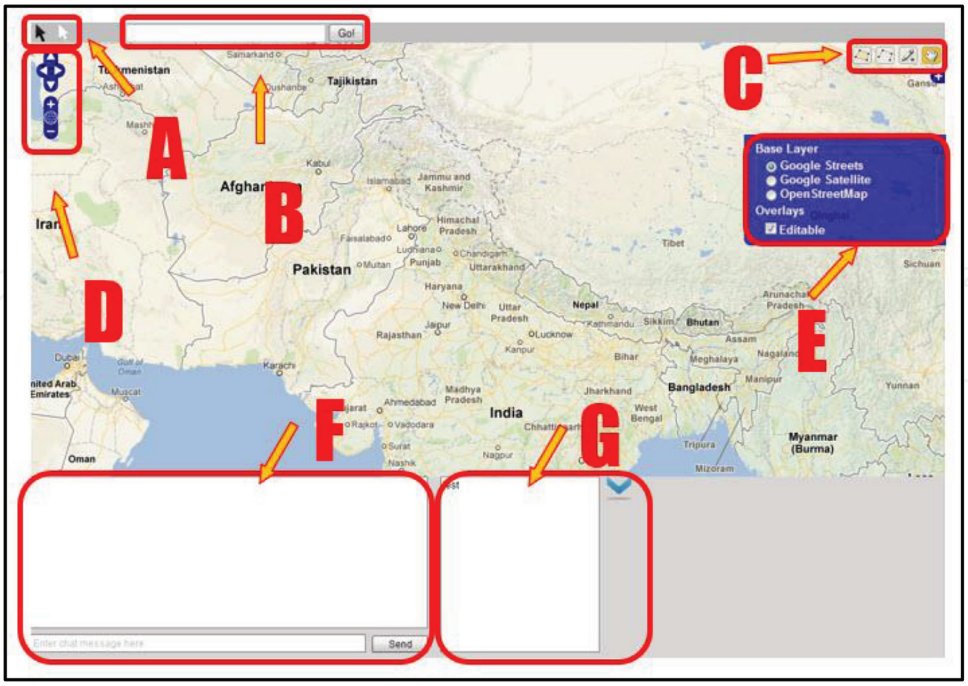

Figure 11. GeoMeeting interface.

organized in a toolbar. To use the annotation tools, click on the appropriate icon on the toolbar and then click on a location on the map or map feature. Add a point, draw a line or draw a polygon. *Caption C* illustrates the textual/graphical notations. A standard toolbar is provided with map zoom-in, zoom-out, and pan functions as shown in *Caption D*. This is basically a typical control in real-time map sharing environment, which allows the user to scroll curser for zooming, left or double-clicks the left mouse button for re-centering the map image to the area where you double-click on the map. *Caption E* is a base layer switcher which is represented by giving and allowing participants to switch between different base maps and including maps given by any Web Map Services (WMS), Open Layer, and the Open Street map layers recording textual and graphical configuration. *Caption F* represents the real-time chatting; it allows any participant in the meeting session to exchange textual information. Chat window panel is developed for sending and receiving messages to other people, as though they are all in the same room, looking at the same map view. In other words, it provides a way for adding remarks linked with the spatial context. The list of participants attending the meeting session is provided through an embedded window panel, shown in a *caption G*. The big down-side blue arrow is used to hide/display the real-time chatting and participants list interface.

5.1.2. Technology

Prototype Web client interface is executed in JavaScript, Adobe Flex, and Action Script. The clients communicate with each other with the application server which is known as Tomcat and real-time messaging server which is Blazeds using a typical set of protocols, i.e., HTTP. The construction of this GeoMeetingV1 makes use of the following technologies such as Web servers (Tomcat), Web map server and tools (GeoServer), Server-side programming (MXML), Client side programming (HTML, JavaScript, Dynamic HTML, ActionScript), Real-time Messaging Server (BlazeDS), and APIs: Google map API V2 and Open layer.

5.1.3. Discussion

The GeoMeeting elements are basically the technological breakthrough in the field of geo-information management. The GeoMeeting is an evolution of map sharing component built previously based on collaborative PPGIS framework, which supports innovative map sharing component technology for better decision-making. There are some issues that need to be addressed and minimized in the upcoming versions of the advanced prototype. At first step, the mouse pointer was used with pixel value that uses screen coordinates for movement of pointer on a map element. But, when it comes to higher or lower resolution, the technique of pointer displays a wrong geographic area. This issue was resolved by justifying the map panel to be left aligned as the problem remained same in center and right alignment, the screen coordinates to initialize from a top-left corner which will be same in all screen sizes, but another problem arises that when mapsharing component was left aligned and displayed on a bigger screen, there is a lot of vacant/empty white space generated on the right-hand side of the screen. This issue will be resolved in the GeoMeeting V2 in which the mouse pointer is synchronized with map coordinates transformation technique instead of using screen coordinates, and participants get the same geographic area as of the moderator.

To make the interface eye catching, the map should be center aligned, but when we center align the map, flash div was moving toward a problem. Flash div is just like a receptacle in the programming language which saves different type of codes in it. Map chat panel and user list are all in different div's and all in the specific percentage, i.e., 100%; when we center align, the flash div's does not visualize the map, chat, and user panel properly. Its solution is sorted out in GeoMeeting V2 by assigning pixel value to chat, and users list div same as of map div in order to visualize it properly. Editing toolbar is used for the demarcation of point, line, and polygon, and a hand tool is used for map panning. Initially, it creates a problem as we select any of them (point, line, polygon, and hand) it did not select properly. In fact, the map container (window) was placed over the editing toolbar, that is why it was creating a problem. As a solution, the editing toolbar's z-axis position was changed (by increasing its z-index value) on the map so that selection of the editing tools can be developed properly and easily. Another issue in the GeoMeeting V1 is that when tools are selected from the editing toolbar and we draw any feature on a map it was not drawn correctly. Many times elements got stuck with the map panel and not allowed it to draw. At the time of development, this issue was seen because of the conflict in different versions launched at different timings. As a solution, old version 2.10 open layer library was replaced with version 2.12 until it was identified and detached from the open layer libraries.

6. Using mock-up case scenarios illustration of the prototype: GeoMeeting implementation in planning and management related activities

GeoMeeting prototype has been used in myriad different fields of studies like public security, crime mapping, disaster occurrences, layout frameworks for preparedness and emergency responses during a disaster, environmental and resources and local government. The section below is comprised of the demonstration of some points using the scenario-based discussion (i.e., the instances come from incidents or cases developed in different regions of the world).

6.1. Scenario 1: GeoMeeting: how well municipalities are meeting the need for parks

As parks are crucial to communities, because parks provide opportunities to people or public for exercise and experience nature which are paramount for physical and mental well-being of humans, it helps in revitalizing local economies; so there is a dire need to estimate park areas and raise municipality residents' living standards. For recognition and generation of easy access to basic essentials of life, such as national parks, green infrastructure, recreation, etc., Government bodies are primarily accountable or answerable because they maintained the available park data but they are not sufficient to fulfill the challenges of data handling and sharing. Therefore, a Web-based GeoMeeting system has been launched to handle and share real-time data, support cooperative meeting sessions at regular intervals, and provide a set of tools like point that helps to recognize park areas and unrevealed base map information about the infrastructure. Video- or audio-based map sharing and Geo-teleconference have been made easy for decision makers to make a decision quickly. Every sort of editing, made by presenter, associated to park marking, will be displayed to all users simultaneously for collaborative decision-making. The presenter can spot a place, add comments, and interpret information related to: park access analysis at city level, complete information and data about every city park, identifying the areas where need of parks is most essential, and recognizing which improvements would provide the greatest advantage to local park system. This sort of

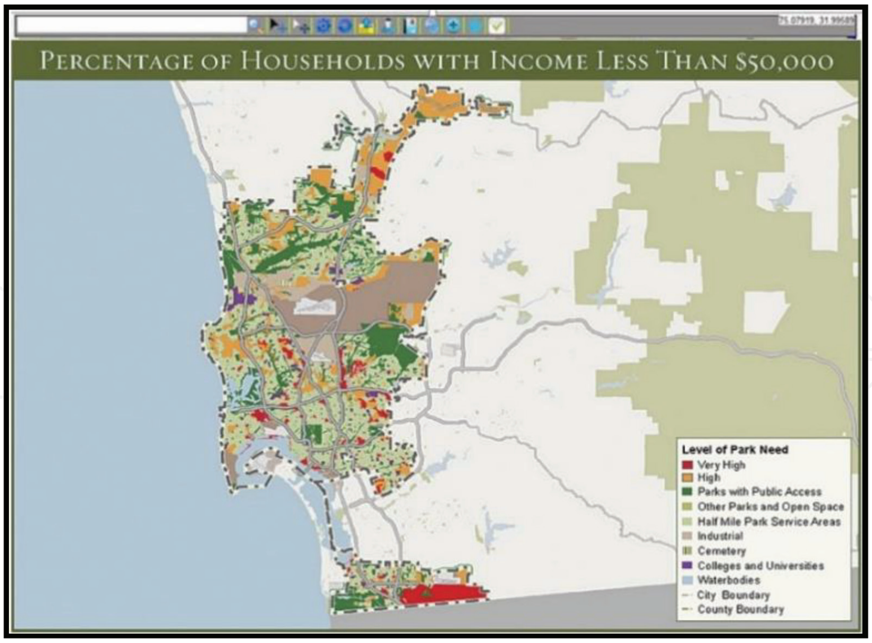

Figure 12. GeoMeeting for municipality parks mapping.

information is accumulated in a database and can be easily recovered. **Figure 12** represents the identified park areas.

Through GIS land use survey techniques, parks are easily determined. In this scenario, android-based techniques are used for collection of park points'. As parks can be easily inspected in high resolution imagery, therefore, high-resolution satellite imagery is used for discussion as a base map. GeoMeeting environment offers the platform for stakeholders to share and execute their views related to area's enhancement by offering better utilities, facilities, and living standards to residents.

7. Usability testing/evaluation

Evaluating the usability testing of GeoMeeting prototype using a case study scenario is helpful to make it effective and usable. A brief summary of steps performed during the usability evaluation of the prototype is discussed as follows.

The evaluation will organized in three parts: (1) a pre-questionnaire comprised of queries related to the user's background, their experience of other Web GIS applications, their computers expertise, and GIS knowledge. (2) Second part of evaluation is the actual user's interaction with the GeoMeeting system using the analytical method with the help of TeamViewer, Session Cam, and Google Analytics tool, which is easy to use, free, and user-friendly usability-evaluating tool that provides a comprehensive set of Website data tracking and analysis tools. By using the TeamViewer and Session Cam recording components, it is possible to collect highly detailed and useful information about the actual usage of the GeoMeeting Website and its components.

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Data elements are valuable for evaluating the usability as well as estimating the degree of public input during the process of participatory planning and effective decision-making. A Web-based feedback component was developed to evaluate and measure the usability aspects collected using pre-post questionnaires and Web analytic tools, i.e., TeamViewer, Google Analytics, and Session Cam. (3) Finally, the users were asked to fill out a post-questionnaire comprised of queries related to usefulness, ease of use or interactivity of using GeoMeeting interfaces in order to collect feedback concerning the usability of the system.

8. 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, lands state, 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/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 built previously based on Collaborative PPGIS framework which accommodate effective and better decision-making through its innovative map sharing component technology.

The infrastructure of GeoMeeting was established on several components-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 any area of interest; synchronously. These components-based services make it an 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.

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