GeoW@re: A Multipurpose Geo-Based Groupware Platform Using Integrated Approach

Mohamed Dbouk
Faculty of Sciences, Lebanese University, Lebanon

Abstract: *This paper describes an integrated groupware platform, called "GeoW@re". GeoW@re approach tends to coordinate competitive works launched by various independent organizations; the main issue is to increase organizations productivity by sharing knowledge. It deals with multipurpose geo-referenced entities (i. e., urban, construction geographic-related projects). GeoW@re can be seen as multipartite inter-organizations coordinator (coordination-board). It incites organizations to adhere to some devoted business rules (a specific coordination protocol). GeoW@re is urban-planning stereotyped tool; most of the concerned organizations apply GIS facilities. GeoW@re consists of an open component-based system, built on top of Linux/Apache technologies. It provides an easy internet support integrating groupware and data warehousing facilities. It was prototyped and validated with satisfaction. Future works consists to find out an ad-equation between GeoW@re and e-learning discipline.*

Keywords: *Groupware, computer support cooperative work, GIS, urban planning, web, data warehousing.*

Received January 3, 2006 ; accepted June 6, 2006

1. Introduction

Day by day, knowledge market is becoming more competitive. Today, technologies supporting computerized information systems are strongly diversified and, boundaries separating computer societies (organizations) become complex to manage. So, *the issue is if and how* collaboration between organizations improves productivity?. The GeoW@re that we propose is an integrated approach trying to answer such issue.

However, collaboration by sharing knowledge increase organizations' potential and reduce efforts, but sharing process may become expensive and difficult to realize due, on one hand, to the nature and complexity of required knowledge and due, on other hand, to the degree of interdependence between organization' projects. Organizations that we consider are diversified, and shown as domain-like *partners*. In urban planning domain we meet, for example, *ministries* of transport and electricity and some specialized *companies*, but in human medical care domain (i. e., anatomy-learning and medical operations), we find academic hospitals and universities. In both examples, partners try to realize some competitive/collaborative projects, called "co-projects", on a certain common area.

In the above domain-examples, knowledge that we consider is geo-referenced. The key element, for the urban-planning case, is the geographic features while for the medical case, the key element is human-organs characterized by some geometric forms and locations.

Reconstructing, for example, a modern city is a complex process. In such process, partners are specialized; each one has its own production tools. A specialized organization digs for telephone installations, a second organization wishes to renew, on the same area, the water-network, and a third organization plans another project. If organizations operate independently and without coordination, a production problem may probably occur; there is no formal guarantee to uncompromise the durability and integrity of the produced work as shown in Figure 1. However, independent constructions are difficult to co-exist on one area. A construction project may influence other competitive projects, which imply considerable losses.

Problems of co-projects constantly appear as long as organizations do not adhere to some common coordination protocol. In practice, sharing knowledge and coordinating organizations' work-plans require the application of a certain process (protocol); such process should solve the inter-dependences between competitive projects. It will be characterized by project's *segmentation* and *serialization*. The common area (Figure 1) that results must integrate, in certain manner, effects of P1, P2, …, and Pn.

We mainly consider three fundamental technologies supporting the aimed GeoW@re platform: Geographic Information Systems (GIS), web facilities and groupware techniques as follows:

- GIS plays an important role in any kind of geo-referenced-based application. However, GIS capabilities represent the ideal environment for providing spatial mapping facilities.

- The Web is now an integral part of most public wide applications. It also represents an easy way reducing deployment costs and facilitating the partner adherence.
- Groupware platform integrates a huge number of sophisticated tools, supporting of course cooperative work requirements; video conferencing, competitive project managing, etc. Groupware applications need to combine and unify knowledge in order to form user-friendly and business-optimal services. So, a knowledge-management center integrating data warehousing techniques is strongly required.

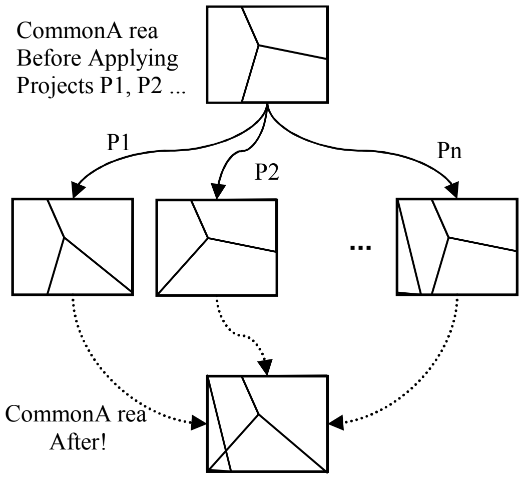


Figure 1. Co-projects and coordination issues.

This paper presents a new approach called GeoW@re, in which the above technologies are combined. In the proposed approach, a GIS-like groupware dialog model is used, it is intended to assist project planners and support project progress monitoring. The transaction message-based competitive model is also adopted. Such model performs system analysis regarding organization-projects interdependencies (required in the realization phase). In one word, GeoW@re can be shown as integrated (environment [1]) technologies forming a high sophisticated groupware platform.

This paper is organized as follows. We present in section 2 a bibliographical study flying over the related research. Section 3 is devoted to the GeoW@re approach, we present the GeoW@re solver model as well as the system design and prototyping model. Finally, section 4 formulates our self critical conclusion.

2. Related Research

Collaboration methods and intended contribution to minimize conflicting processes incite researches to explore this domain. Recent escalated events such as natural disasters like Tsunami (December 2004) and Katrina (August 2005) argue the need for collaborative work with geo-spatial/position data. The term collaboration is widely used in many varying contexts such as sciences, education, art and business, very little research has been carried out to discover this process's properties [15].

Attempts to provide collaborative frameworks have been reported by many initiatives and researches, most of them are specialized in urban and spatial planning [8, 12, 17, 19, 20]. Some others are web-based learning tools [5, 6], such tools can be subject to integrate in one contextual collaborative framework. In the context of GIS, [2, 3, 18] observe that such frameworks require Computer Support Cooperative Work (CSCW) like tools in one hand, and in the other hand they should apply some workflow modeling and collaboration management policy.

The term "geocollaboration", for example, is recently used by some researchers in order to describe the collaboration approach. A useful bibliography is reported in [15], we extract some useful studies. Collaboration is very important to coordinate efforts. One level of collaboration in a geospatial context involves sharing of data and/or applications by and among various organizations. An example of a collaborative GIS tool that has been developed to support multi-agency cooperative work with geospatial data is the Geospatial One-Stop (GOS). It uses the approach of providing portals or channels to various web sites that support sharing of geospatial data and applications.

The GOS[1] is a helpful site. It provides information about latest natural disaster like hurricane Katrina. Data inside are organized by categories such as geological features and processes, agriculture and farming (soil resources, water resources), fire mapping, etc. One example of an application that is accessible from GOS is "the interactive hurricane Katrina disaster viewer[2]", this viewer is a hyper map-like. Another example is the GeoMAC wildfire information website. GOS site reports that: "The Geospatial Multi-Agency Coordination Group or GeoMAC, is an Internet-based mapping tool originally designed for fire managers to access online maps of current fire locations and perimeters in 12 western states. Using a standard web browser, fire personnel can download this information to pinpoint the affected areas".

According to [17], most geospatial technology has been developed to support a single user at a time. More research is needed to support group decision-making processes based on geospatial data visualization, especially in a synchronous (real-time) communication mode. There has been little progress made in the field of commercial software to provide collaborative tools that are integrated with geospatial analysis activities. Examples of geocollaboration tools:

[1] http://www.geodata.gov/gos.
[2] http://arcweb.esri.com/sc/hurricane_viewer/index.html.

- GeoConnections[3] initiative in 2002 trying to make "Canada's geospatial databases, tools and services readily accessible on-line".
- The GeoCAS[4], Pacific Disaster Center (PDC) system is based on a distributed data sharing network, it is built on top of Integrated Decision Support System (IDSS). It has been developed by PDC.

However, an interesting aged web-based mediation approach, called GeoMed, is reported in [8], GeoMed was a pilot project launched by the European community in January, 1996. It is based on the Zeno system [11] (for same firm; mediation on Internet; spatial planning). Zeno run on network of computers, it was developed within German National Research Center for Information Technology, System Design Technology Institute (GMD) in 1995. GeoMed applies the "online map" concepts of [23]. It can be considered as a good example of coordination assistant tool.

Moreover, in the context of geo-referenced knowledge sharing, some learning tools should be considered. As reported in [5, 6], the digital anatomist project done by the University of Washington is a repository of annotated static 2D images. The human body seen as a hypermap, learner can easily browse and navigate through the organs by clicking on small icons. Neither 3D images nor video are supported, the spatial relationships between organs are under perceived. However, tools like [13] remedy the gap, it fully invest on the multimedia effects, like 2D and 3D animated images, film and movies as well as text and sound are also used. As learning e-anatomic tools, [13] can be considered as a very good tools, it is recommended to be extended in order to support collaborative web-based learning and real-time medical operations monitoring tools.

In one word, each one of the above studied approaches can be shown as a dedicated tool but never as multipurpose platform integrating multiple technologies. Finally, the inter-organization issues like data sharing and data integration aren't yet solved and can't represent the object of this current paper. Useful bibliography is reported in [7, 9, 22].

3. GeoW@re Approach

GeoW@re that we propose is a collaboration platform applying the coordination aspects reported in [21]. GeoW@re is able to be customized. GeoW@re tends to be a public-participation information system involving a group of computer-sites (partner organizations). It represents a partnership assistant tool coordinating organization's competitive works.

[3]http://www.geoconnections.org/CGDI.cfm/fuseaction/home.welcome/gcs.cfm/index.http.

[4]http://www.pdc.org/iweb/index.jsp.

3.1. GeoW@re S.V. Other Approaches

GeoW@re can't be seen as any above discovered approaches, it breeds, in certain way, for example GeoMed, and anatomist leaning and monitoring tools. In other hand, GeoW@re can provide viewing services similar to the Katrina disaster viewer. However, rather than the "be customized (platform)" characteristic, GeoW@re mainly differs, from other approaches by the introduction of the "general committee of coordination (virtual organization)". Such committee meets the "collaborative workspace; virtual environment" reported in [2, 25].

3.2. GeoW@re As a Coordination Board

GeoW@re can be seen as a general inter-organization planning committee (coordination board). It may be considered as a specialized virtual organization (Figure 2). The issue is to incite organizations to participate to a common and formal inter-site agreement.

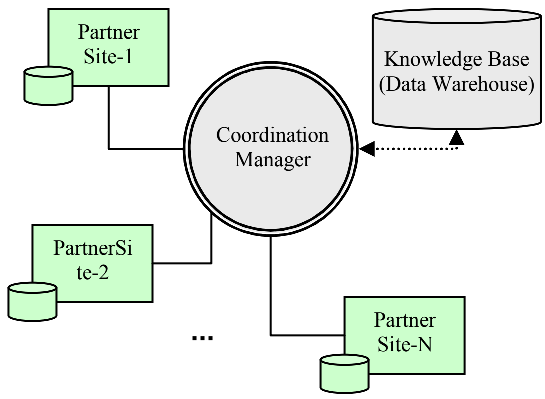


Figure 2. GeoW@re; a general committee of coordination (coordination board).

So, such committee applies a set of management/business rules and mechanisms which formulating the "coordination protocol". In [23], we speak about virtual environment as a shared project workspace that uses shared databases, a set of collaborative functions and collection of digital files and permits definition of group members' roles.

However, the elaboration of such protocol requires considering and assuring the following fundamental assumptions:

- *Sites-Independencies*: Guaranteeing a high degree of transparency.
- *Knowledge Sharing and Availability*: Knowledge stay consistent against competition, interoperability and standardization issues.
- *Personalized and Site-Friendly Environments*: Facilitating site integration and site adherence.

Finally, GeoW@re consists of a huge and great amount of information distributed through tens of computer-sites. It can be characterized by merging groupware mechanisms and data warehousing facilities.

3.3. GeoW@re Solver Model

GeoW@re system plans competitive works (projects) and tracks progress. Information that GeoW@re manages is very huge. It applies the following basic features:

- *Multipurpose Entity (ME)*: An ME represents an elementary and encapsulated set of interrelated information. In urban planning case, ME may be a road, or any kind of urban entities.
- *Shape:* Usually contains a great amount of MEs.
- *Organization (Partner)*: Can be seen as a computer-site having an armada of materials, dedicated equipments and software packages (i. e., GIS, etc.).
- *Conflict-ME*: An ME requested from multiple organizations.
- *Competitive-Project (C-Project)*: Sequence of actions initiated by a certain organization. Usually, a CP involves some conflicting MEs within certain shape.

3.3.1. Formal Competition Model (FCM)

Basically, organizations establish construction-sites by applying project engineering management techniques. GeoW@re readapts the project life cycle in order to provide a multi-partite competition model. The organization launching project has to initiate a cooperative pre-preliminary study. Such task decorticates any conflict between each parties; it allows to avoid cases such that seen in Figure 3-a when projects P1 and P2 share the same area and sub-shape.

Formally, the equation is: $S_a = P_i (S_b)$, b < a, where a and b are time representations, P_i, process translating a shape S_b into a new shape S_a, the process is launched by one organization "i".

- *Serialisiblity*: If project Pi and Pj share nothing, we say that Pi and Pj are parallel, if not (above case), Pi and Pj must be serialisable. Projects owner are invited to *negotiate* some agreement by providing an adequate scenario, for example P1 then P2 or P2 then P1 as shown in Figure 3-b.
- *Segmentation*: Conflict projects can be segmented (decomposed) into sub-projects. Result appears in a new graph looks like activity network graph (e. g., PERT chart). Then, the competition solving process is rerun.

3.3.2. Formal Data Distribution Model (FDDM)

Computer sites representing partner organizations form together the groupware network; such network is represented by means of a directed graph: Nodes represent the participating sites, and links are labeled expressing data sharing between sites (Figure 4).

Sites are of two categories according to considered MEs: Producer and consumer:

- A producer site "Sp", also called *master*, of an ME; means that Sp administers the primary and up-to-date version of such entity.
- A site is consumer "Sc", or client, when it seeks a ME from one Sp. Sc applies reading and/or writing operations.

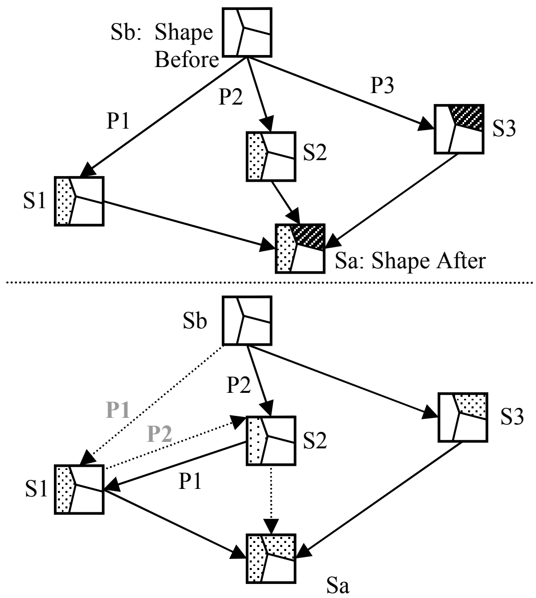


Figure 3. Serializing projects.

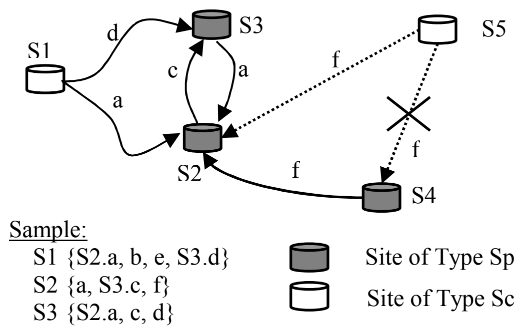


Figure 4. Formal data distribution configuration.

The network of sites seen as a complex configuration, sites of type Sp are numerous and the distribution of load is not homogeneous. We distinguish two main configurations (topologies) as follows:

- Centralized; they are one and only one Sp site and several Sc sites.
- N-centralized or hyper-centralized direct graph; links such <S5, S4, f> should not exist, because S4 is of type Sp on f; it will be replaced by <S5, S2, f>. So, every site may be of type Sp and/or Sc. Each Sp constitutes a sub-centralized configuration, it maintains a proprietary local data distribution catalog; S2 and S3 as Sp sites should maintain properties such as the example: <S3/Sp, {S1, S2}/Sc>, <S2/Sp, {S1, S3, S4 et S5}/Sc>, etc.

A brief pros/cons analysis leads to opt for the hyper-centralized configuration. Local catalogs all together constitute the global "GeoW@re data distribution catalog". Such crucial metadata will, constantly, be solicited by any knowledge-sharing related operations.

3.3.3. Knowledge Sharing Approach

Knowledge sharing is the main issue of GeoW@re. With respect to inter-site independency criteria, many questions should be fixed; especially, which kind of MEs format to consider? And how MEs can be transited?

Actually, each site (organization) may have some proprietary MEs format. So, to answer the first question, GeoW@re opts for a common and public-wide data exchange format, such that (for example) used by ESRI products for any GIS purposes. Partners are even invited to comply with such GeoW@re requirement.

However, once MEs are GeoW@re reformatted; they can easily be shared by applying an offline up and/or down-loading, on demand operations. Data transition is, of course, done with respect to the GeoW@re coordination model.

Moreover, GeoW@re MEs as well as any proprietary entities such that describing C-projects, shapes, shortcut links, etc. should be archived. So, in the course of time, a huge amount of data will appear. Such data constitutes the GeoW@re devoted data-warehouse [16].

3.3.4. Coordination Model

Coordination between sites is done by mean of a specific protocol; it consists of a set of operational rules mainly inspired from the technique of transaction managing. GeoW@re distinguishes three major operational phases (Figure 5) as follows:

- *Subscription*: Where organization adheres to the system,
- *Activity*: Where organization becomes member of the general coordination committee and tends to realize projects.
- *Retirement*: Where organization quit definitely the working group.

In detail, during the phase "activity", organization submits projects and constitutes working sessions, this phase consists of three successive stages as follows:

- *Preparation "Pre-Session"*: Terrain and electronic negotiation using multimedia facilities. They lead to elaborate a cooperative project plan.
- *Opening Session*: Project will be registered. Target MEs (elements of project's shape) will be locked. By looking at the repository, partners would be able, during the working period, to follow and track evolutions on the considered area.
- *Closing "Post-Session"*: Posting new versions of the considered MEs (become primary, each on the owner site), unlocking entities, re-synchronizing ME versions (alert partners), archiving project, closing down the project.

This model constitutes a huge and complex process merging between groupware techniques and project competition philosophy. This coordination model requires to be installed on an offline transactional or message-like mode.

3.4. System Design

GeoW@re approach is characterized, on one hand by the integration of multiple software components, and on the other hand by a reliable application model.

3.4.1. Component Based Architecture

The software architecture of GeoW@re mainly consists of a dedicated repository and four specialized interrelated managers supporting the above models (Figure 6) as follows:

- *GeoW@re Repository*: Supporting two data groups:
  - Up-to-date global catalog describing the repartition of the shared MEs.
  - Repository system-database tracing the various projects working sessions.
- *Sign in Manager*: Administering partners life cycle; adhesion and retirement.
- *Project Submission Manager*: Mainly supporting, for each submitted project, the pre-session phase and any related process.
- *Session Manager*: It administers partner sessions and applies any groupware-like operations: Online dialogue, video conferencing, messaging, planning. Competitive projects are supported via a transaction-like dedicated controller.
- *Data Warehousing Manager*: Providing inter-site data transfer facilities (download, upload, etc.). This manager, also, archives up-to-date details on any public devoted activity inside GeoW@re; e. g., C-project's features, latest MEs development, etc.

GeoW@re can be seen as an open system; new and dedicated components can be added with respect to the new technologies. GeoW@re applies a transaction-like protocol supporting competition and multipurpose data (MEs) re-synchronization. Such protocol is message-based respecting a total independence between organizations.

Finally, the repository database is used by the system in order to describe working sessions. It forms a support of auditing, monitoring and following-up of current projects. Moreover, the data-warehouse sub-system is the advanced engine supplying all GeoW@re users with any post-projects information.

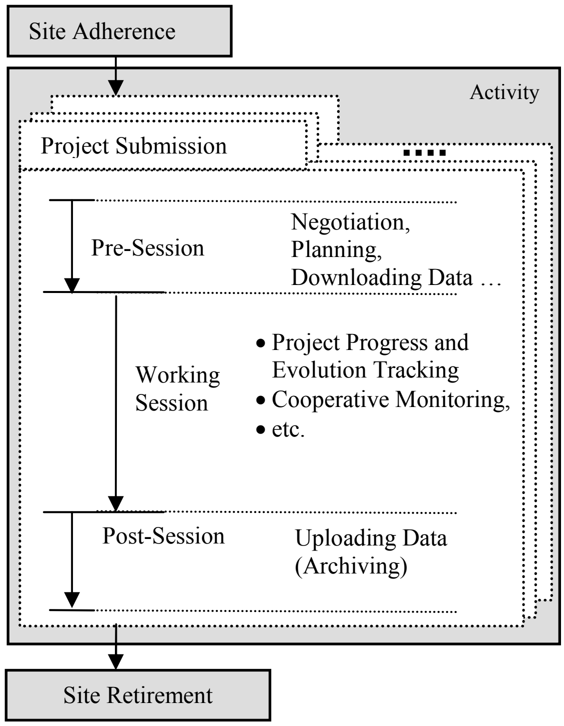


Figure 5. Inter-sites coordination protocol.

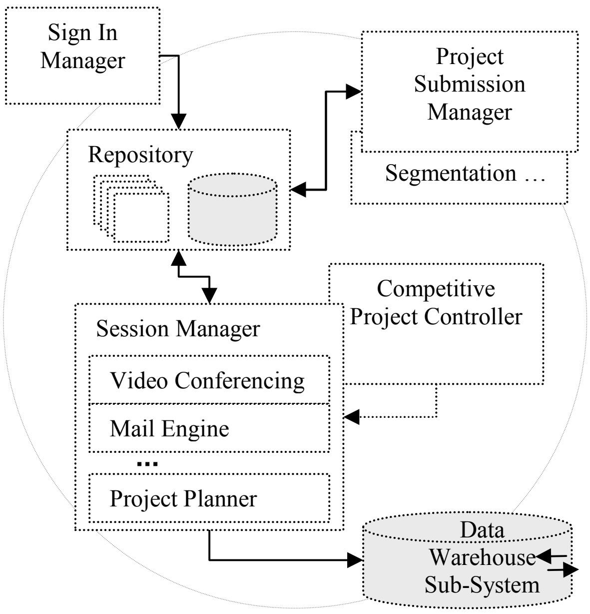


Figure 6. GeoW@re general software architecture.

3.4.2. Applied Architecture

GeoW@re is established around an integrated engine supporting groupware services. It mainly considers knowledge sharing between independent organizations. GeoW@re is characterized by reliable deployment architecture; it also applies a dedicated dialog model. GeoW@re deployment architecture; two types are considered as follows:

- *Centralized*: Only one site hosting GeoW@re. It means that, despite of numerous Sp sites, all knowledge sharing issues are routed via this special site.
- *Distributed*: Where every Sp site establishes its own well set-up sub-GeoW@re. Now, GeoW@re will be seen as a hyper-centralized system (Figure 7).

Beside the complexity and the knowledge resynchronization issues, the distributed solution requires some specialized and dedicated inter-GeoW@re links. Such solution is so expensive and difficult to maintain, thus, the centralized option site where GeoW@re is hosted is recommended.

GeoW@re dialogue model is, on one hand, groupware-like model manipulating with descriptive information from repository meta-data, and on another hand, GeoW@re is a GIS-like graphical user interface (Figure 8); it applies techniques of type hyper-map as follows:

- Shapes are seen as cartographic view of the considered working areas.
- Shared MEs, partner-sites on considered MEs, active projects, geo-positioned cameras, etc. are seen as reactive, on shape, graphical objects.
- Updates from-repository hyperlinks and navigation facilities.

GeoW@re distinguishes two main site profiles; one for partners of type Sp and the second for partners of type Sc. Members of GeoW@re community are able to: Submit projects, follow up current projects, video conferencing partners, upload and download MEs, etc.

Finally, we consider that any GeoW@re entity is the cooperation between content and GeoW@re compatible interfaces. GeoW@re opts for the object advanced technology; shared entities are assimilated to exchangeable software components.

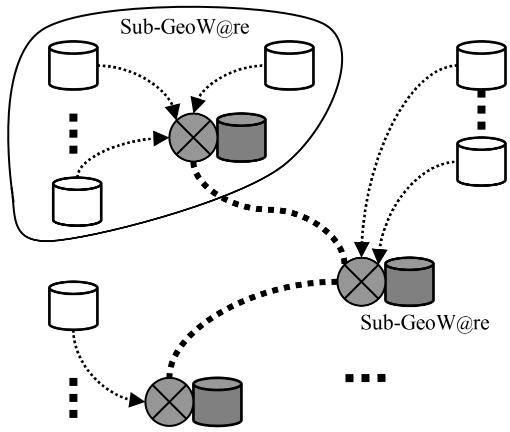


Figure 7. GeoW@re implementation approaches.

4. Prototyping and Validation

Diversity and independency of partner sites, cost issues, reliability, easy-deployment and maintainability of the intended system are considered in our process to find out costless technical solution. All of these criteria lead to opt for the web technology as main development platform.

Web technology meets the main fundamental GeoW@re business requirements: Mobility and online issues, easy to become operational, no need to install a dedicated network, maturity and evolutionary of adopted technology.

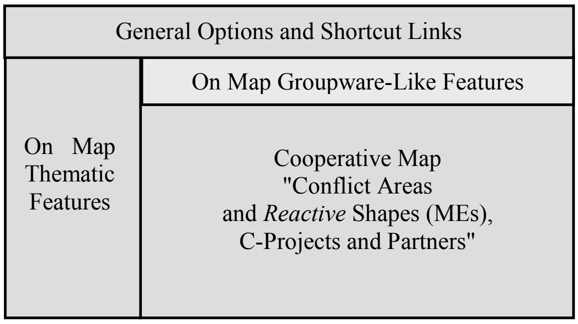


Figure 8. Hypermap [4] and GIS-like user interface.

4.1. Prototyping Packages

GeoW@re first prototype is assimilated to a 3-tier coupled architecture (Figure 9) as follows:

1. One devoted web site, it was validated using the *Linux* technology (the fist version is down using the Microsoft technology): Apache web server, most of graphical user interface facilities are implemented by mixing PHP and java features.
2. MySQL repository database.
3. Application server hosting all GeoW@re business requirements, and supplying any groupware-like and multimedia facilities.

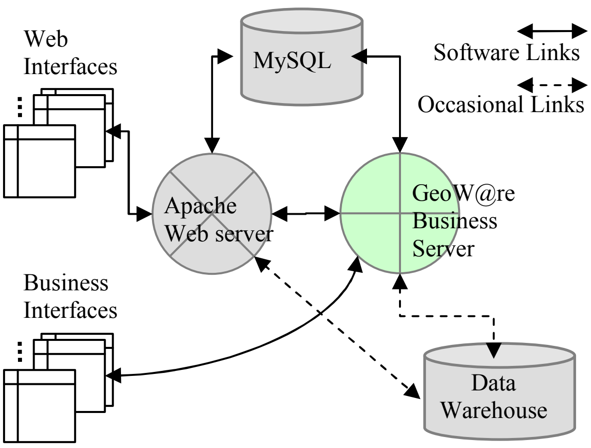


Figure 9. Component-based prototyping configuration.

Finally, a fourth outside late component (data warehouse) is added in order to provide a future data mining support.

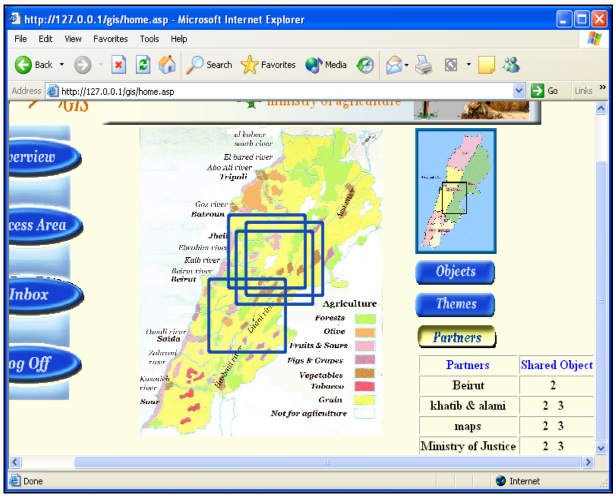
4.2. Testing and Evaluation

GeoW@re was tested by creating many sample organizations (masters and customers) and, by performing the following main operations:

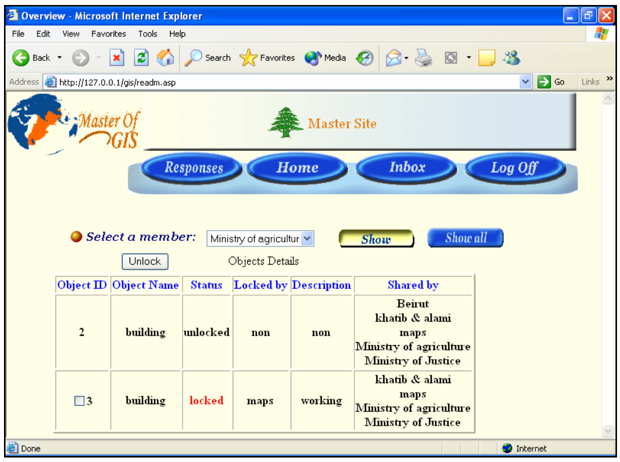
- Deeply exploring considered area and entities by both categories of users.
- Submitting/launching projects by some customers.
- Managing requests from customers by master users.
- Scheduling conference between certain customers.
- Exploring/updating entity status by master users (Figure 10-a).
- Dialog interaction between some group partners.
- Exploring entities of other organizations.

The following forms (Figure 10) briefly demonstrate the collaboration main issue; a multiple projects (box links in Figure 10-a) can easily be coordinated and followed-up inside one GeoW@re cooperative map.

First results are encouraging; subscription, projects submission, sessions and projects follow-up were implanted with satisfaction, other services are planned. A multimedia extension is planned also; geo-installing, on construction-sites, a network of digital cameras. Finally, the question "how GeoW@re contributes to e-learning discipline?" is under study.



(a). A member seeing his partners.



(b). Master exploring shared entities by a certain customer.

Figure 10. Forms of collaboration.

5. Conclusion

GeoW@re approach tends to be a powerful platform; it is seen as an inter-organizations coordination-board. Organizations operate in common geo-referenced areas. The main issue was to increase productivity by sharing knowledge, reducing efforts and by coordinating works.

GeoW@re integrates numerous technologies; it is of type groupware dealing with independent organizations. It also deals with multipurpose geo-referenced entities and, applies the most advanced knowledge sharing and competition techniques. It uses hyper-map features. Data warehousing facilities are integrated by means of an after partner-working sessions archive. GeoW@re, is assimilated to a 3/4-tier web site, mainly built on-top of Linux technology; Apache, MySql. Prototyping and evaluation phase confirms and validates the intended issues; it demonstrates how many such approach is useful. Briefly, results are very interesting.

However, it is so difficult to apply a full automated coordination process. We notice that, a "GeoW@re-master", administering inter-organizations dialog, is required. Finally, rather than the data warehousing techniques, finding out an ad-equation between GeoW@re and e-learning discipline should influence our future works.

References

[1] Bell P., Davis E. A., and Linn M. C., "The Knowledge Integration Environment: Theory and Design," *in Proceedings of the CSCL'95*, available at: http://www.kie.berkeley.edu/KIE/info/publications/theory&design.html, 1995.

[2] Bouras C., Giannaka E., and Tsiatsos T., "Designing Virtual Spaces to Support Learning Communities and e-Collaboration," *in 5th IEEE International Conference on Advanced Learning Technologies (ICALT'05)*, pp. 328-332, 2005.

[3] Coleman D. J. and Li S., "Developing a Groupware-Based Prototype to Support Geomatic Production Management," *Computers, Environment and Urban Systems*, vol. 23, no. 4, pp. 1-17, 1999.

[4] Dbouk M., Kvedarauskas D., and Boursier P., "Dynamic Maps: An Intuitive Interface for Naive Users of Spatial Database Systems," *in Proceedings of the 3rd International Workshop on Interfaces to Databases*, Napier University, Edinburgh, July 1996.

[5] Digital Anatomist Project, "The Digital Anatomist Information System," Structural Informatics Group (SIG), Department of Biological Sructure, University of Washington, available at: http://sig.biostr.washington.edu/projects/da, 2005.

[6] Eldrandaly K., Eldin N, Sui1 D., Shouman M., and Nawara G., "Integrating GIS and MCDM Using COM Technology," *International Arab Journal of Information Technology*, vol. 2, no. 2, pp. 162-167, April 2005.

[7] El-Khalili N., "Web-Based Anatomy Computer-Aided Learning Tools," *International Arab Journal of Information Technology*, vol. 2, no. 3, pp. 177-182, July 2005.

[8] GeoMed, URL; GMD: German National Research Center for Information Technology, available at: http://www-fit-ki.gmd.de; http://arti4.vub.ac.be/previous_projects/geomed/geomed.html, 2005.

[9] Goodchild M., Egenhofer M., Fegeas R., and Kottman C., *Interoperating Geographic Information Systems*, The Kluwer International Series in Engineering and Computer Science, Kluwer Academic Publishers, 1999.

[10] Gordon T. F., "Zeno: A WWW System for Geographical Mediation, in Collaborative Spatial Decision-Making," *Scientific Report for the Initiative 17 Specialist Meeting*, Santa Barbara, CA, NCGIA Technical Report 95-14, September 1995.

[11] Gordon T., Karacapilidis N., Voss H., and Zauke A., "Computer-Mediated Co-Operative Spatial Planning," in Timmermans H. (Ed), *Decision Support Systems in Urban Planning*, E & FN Spon Publishers, pp. 299-309, 1997.

[12] Gordon T. and Karacapilidis N. I., "The Zeno Argumentation Framework," *in Proceedings of Proceedings of the 6th International Conference on AI and Law (ICAIL'97)*, Melbourne, Australia, ACM Press, pp. 10-18, 1997.

[13] Humani Coporis Fabrica, 3D Anatomical Atlas, available at: http://www.hcfmultimedia.com/new_pag/hcf.htm, 2005.

[14] Jones R., Copas C., and Edwards E., "GIS Support for Distributed Group-Work in Regional Planning," *International Journal of Geographical Information Science*, vol. 11, no. 1, pp. 53-71, 1997.

[15] Judd D. D., "Geocollaboration Using Peer-Peer GIS," *Directions Magazine*, available at: http://www.directionsag.com, 2005.

[16] Kerschbergm L., "Knowledge Management in Heterogeneous Data Warehouse Environments," *in Proceedings of the 3rd International Conference on Data Warehousing and Knowledge Discovery*, Springer, vol. 2114, pp. 1-10, 2001.

[17] Laurini R., "Information Systems for Urban Planning: A Hypermedia Cooperative Approach," available at: http://lisi.insa-lyon.fr/~laurini/isup, 2001.

[18] Li S. and Coleman D. J., "Results of CSCW Supported Collaborative GIS Data Production: An Internet Based Solution," *in Proceedings of the Symposium on Geospatial Theory, Processing and Application*, Ottawa, 2002.

[19] MacEachren A. M., Brewer I., Cai G., and Chen J., Visually Enabled Geocollaboration to Support

Data Exploration and Decision-Making," *in Proceedings of the 21st International Cartographic Conference*, Durban, South Africa, August 2003.

[20] MacEachren A. M., Cai G., Sharma R., Rauschert I., Brewer I., Bolelli L., Shaparenko B., Fuhrmann S., Wang H., "Enabling Collaborative Geoinformation Access and Decision-Making Through a Natural, Multimodal Interface," *International Journal of Geographical Information Science*, vol. 19, no. 3, pp. 293-317, 2005.

[21] Medeiros S. P. J., de Souza J. M., Strauch J. C. M., and Pinto G. R. B., "Coordination Aspects in a Spatial Group Decision Support Collaborative System," *in Proceedings of Symposium on Applied Computing, Proceedings of the 2001'ACM Symposium on Applied Computing*, Nevada, USA, pp. 182-186, 2001.

[22] Mostafai S., Bouras A., and Batouche M., "Data Integration in a PLM Perspective for Mechanical Products," *International Arab Journal of Information Technology*, vol. 2, no. 2, pp. 141-147, April 2005.

[23] Rennir C., "Argumentation Maps: GIS-Based Discussion Support for Online Planning," *PhD Thesis*, University-of-Bonn, Germany, available at: http://www.gmd.de/publications/research/1999/022, 1999.

[24] Sarjakoski T., "Networked GIS for Public Participation in Spatial Planning and Decision-Making," *in Proceedings of the 18th ICA/ACI International Cartographic Conference*, Stockholm, Sweden, pp. 1859-1868, February 1998.

[25] Takemura H., Kishino F., "Cooperative Work Environment Using Virtual Workspace," *in Proceedings of CSCW'92*, Toronto, New York, ACM, pp. 226-232, November 1992.

Mohamed Dbouk received his Bachelor's Honor in applied mathematics; computer science, Faculty of Sciences (I), Lebanese University, Lebanon, his PhD in geographical information systems from Paris-11 University, Orsay-France, in 1996. Currently, he is the director and an associate professor, Faculty of Sciences (I), Lebanese University, Lebanon. He has research and publications in GIS, 3D modeling, groupware, GUI, and interoperability, and technical experience in enterprise information systems. He is a technical expert of the Avicenna Distant-Learning Project (Unesco). His research interests include software engineering and information systems, and GIS.