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Research on Spatial Knowledge System of Heterogeneous Spatial Information based on Cloud Computing Technology

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Abstract

The traditional collaborative plotting system only allows one online user to plot the information and the data between users cannot be shared. Therefore, in modern society, it is unable to meet the needs for multiuse's' plotting online at the same time. Spatial knowledge system of heterogeneous spatial information based on cloud computing technology presented in this paper realized high concurrency and high online number of the collaborative plotting. It can dynamically collect global information and enhance the communication and collaboration between users. The system increases the spatial information services to high levels of global spatial knowledge cloud services. Experiments show that this system can realize the multiuse's online plotting; meanwhile it has fast response time and good stability.

Keywords: *Collaborative Plotting System; Spatial information; Online plotting; heterogeneous; Multiuser; Cloud computing; Multi-agent; Cloud service; Spatial data type; Identity authentication*

1. Introduction

With the development of society and the popularity of GIS[1]., people pay more attention to the geographic information, and have higher requirements for the acquisition and use of geographic information, which mainly include: Spatial Information Collaborative mapping needs; global dynamic heterogeneous spatial information[2]. integration needs; dynamic heterogeneous spatial data mining needs; building spatial analysis cloud computing model, providing GIS cloud service[3]. needs.

The main purpose of the spatial knowledge system of heterogeneous spatial information[4]. based on cloud computing technology is to build the global map heterogeneous spatial collaborative plotting model, using the capability of lateral spreading and distributed characteristics of cloud computing to achieve high concurrency, high online user number of Collaborative Plotting. And then the dynamic collection of global information is achieved, getting rid of the island effect of spatial information in the past, enhancing the ability to collaborate and communicate between the relevant spatial information users and the deep level mining information capability. It will improve the spatial information services to the world's high level of spatial knowledge cloud services.

2. System Service

2.1 Collaborative Design

The so-called cooperation means to the process or ability to coordinate two or more than two different resources or individuals to complete a certain goal. Generally speaking, the most important collaborative application is to realize the

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information collaboration, business collaboration and resource coordination. From a technical perspective, a new application system not only needs a good overall strategy, but also needs a better technical support system. At present, some popular collaborative software on the market mainly adopt the system structure of "B/S" (Browser/server), the advantages are the low maintenance cost, strong exchange ability, the unified operation style, and it is convenient to implement centralized management for server and database.

2.2 The Provided Services

Collaborative plotting cloud service system includes the following services: dynamic heterogeneous information acquisition, global dynamic heterogeneous information access service based on virtual resource pool, adaptive real-time/quasi real time display services of plotting information, dynamic heterogeneous information updating service, establishment of global geographical names database, the construction of hybrid collaborative mapping model based on Multi-Agent[5]., the role access control service based on identity authentication, the cooperative service[6]. for multi user operation, Collaborative Plotting conflict resolution services. The data layer of the system and the service module of the collaborative plotting will use the architecture of Figure 1.

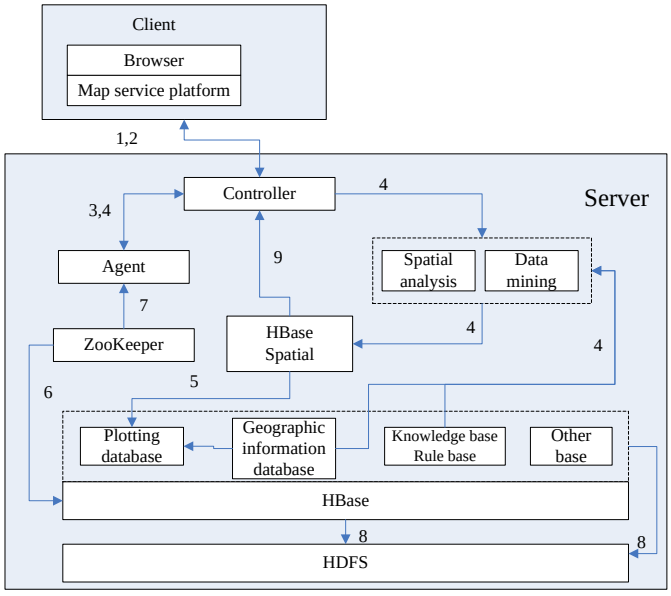

Figure 1. The Service Module of the Collaborative Plotting

The instructions about the service module:

1. The user requests the server to provide the required geographic data, the user's request which the server received are distributed by the controller, the basic map image is provided by the Quad Server, the other request data is converted into the object model by the controller to form the XML file which will be sent to the browser and perform the JavaScript program to convert into images or users' GIS data;
2. Users not only submit the standard plotting information to the server, but also submit some information like personal information and verification. Server controller receives users' information, and convert the Java object into GIS data, send them to the cloud platform for processing;
3. Agent can perceive the accepting request of the controller, and analyze the data. To deal with the data redundancy and conflict through the detection mechanism, it will

restrain the integrity and reliability of the data;

4. The data processed by the Agent is collected by the controller. After making the spatial analysis and data mining for the data information, it will integrate the original plotting data and send them to the HBase Spatial finally;
5. The design of HBase Spatial is similar to Oracle Spatial. The specific data types and structures are designed to store the spatial information, and the spatial information is stored in the real database;
6. HBase distributed database depends on zookeeper, HBase provides a non- relational database storage service for the whole system. For the GIS data, it can provide a better service than the relational database in theory;
7. The design of server Agent is similar to HBase's Master-slaves structure; it uses Master's Election mechanism of zookeeper to ensure the Master of the server agent can work well. In addition to the initial query, the client agent works with the slave of the server agent in order to reduce the data transmission between the server cluster, the server agent uses cache to improve the efficiency;
8. HBase data documents is stored in HDFS in the form of files, MemStore and other technologies can provide the random storage ,small file storage and other functions for the top of HDFS which is hardly provided by itself. Most of the information in the system is stored in HBase, but some information which is difficult to process directly by the HBase will be also stored in HDFS directly;
9. Server agent interacts with the database and updates the contents in the cache; it will ensure that the user can obtain the latest information.

3. The Design of Collaborative Plotting System

3.1 The Design of Collaborative Plotting System Database

We classified the spatial data types into three basic types: point, line and relationship. The three basic types have evolved many kinds of spatial data types. The point, an object attribute with a latitude and longitude, and with additional attribute list of keys, can accurately and uniquely identify the condition of a position. Line can be divided into three types: the closed coil, non closed coil and region, the unclosed-ending line usually indicates roads, rivers, rails etc. The closed-ending line indicates ring roads and subway. The relationship, composed by a series of points and lines and defined by role, is a kind of implicit data type. It is a relationship among the entities. Tag label is not a basic map element, while map elements record the relevant attribute key value in the form of Key/Value through Tag.

The logical design of the database, transformed from the E-R diagram to the relational schema, is to convert the conceptual model into a general relational model. That is, the relationship among the entities, the attributes of the entities and the entities of the E-R diagram is transformed into a relational schema.

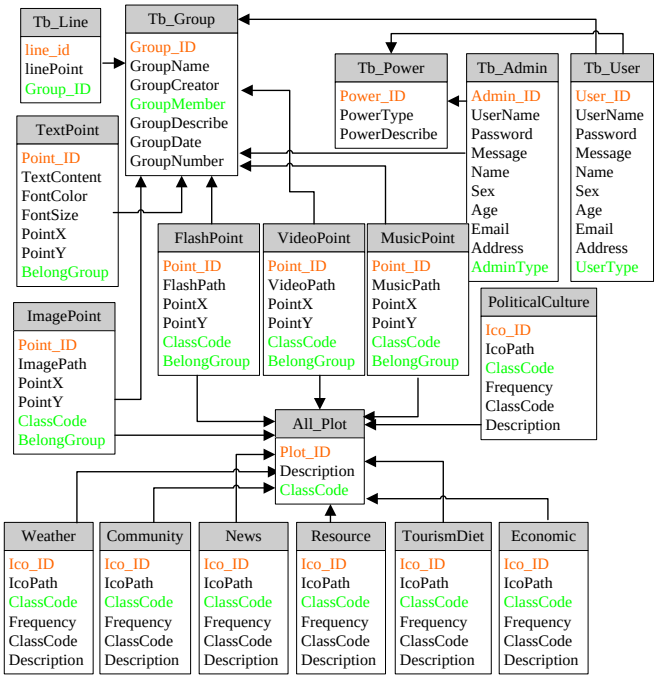

Figure 2. Collaborative Plotting Database Design

3.2 The Front-end Design of the System

3.2.1 The Plotting type: The user can choose the picture plotting, flash plotting, the audio plotting, the text plotting, the video plotting, and the three-dimensional model plotting on the plotting layer, as shown in Figure 3:

Figure 3. The Plotting Interface of The Front-end System

3.2.2 The collection of plotting data: As the plotting is done in client front-end, we use JavaScript to get the data in the data acquisition. The icon information collected on the plotting layer is different according to the plotting type. The information collected in

the picture includes the longitude, latitude of the plotting point, the storage path of the icon on the server, and the HTML code when the icon is clicked. The information collected in the flash plotting mainly includes the longitude and latitude of the flash plotting points, the storage location of plotting files on the server, and the HTML code when the file is clicked. The information collected in the audio plotting mainly includes the longitude and latitude of the plotting point and the storage location of the audio file on the server, and the HTML code when the target is clicked. The information collected in the text plotting mainly includes the longitude and latitude of the plotting point, and the color, size and content of the text. There is a unique ID in all these plotting files, and the ID provides a convenience for the CRUD(create, retrieve, update, delete) operations of the icon.

3.3 The Overall Design Process of the System

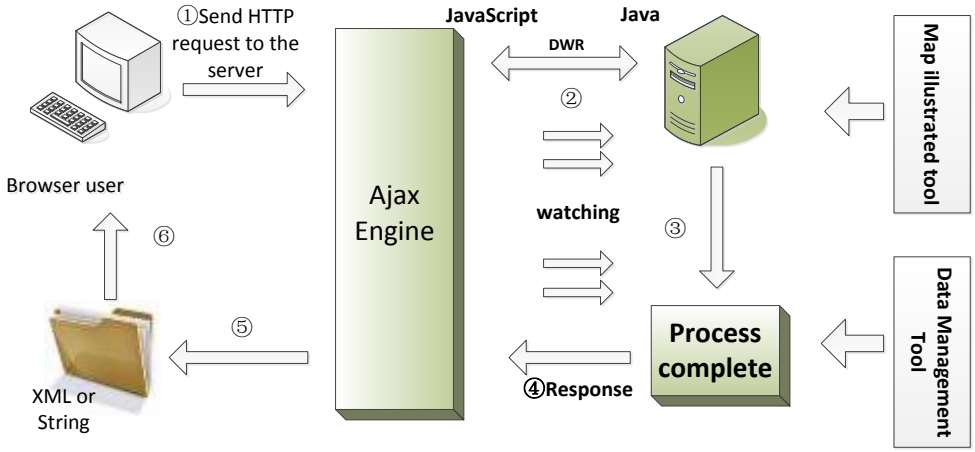

Figure 4. Data Flow Chart of Collaborative Plotting

The process that user access the Collaborative Plotting system is as follows:

1. Users can login, register and do other operations through HTTP protocol of the terminal browser, send forms to the server and wait for the response.
2. Ajax engine monitoring system is built on the server. It can monitor the changes of the server's internal state in real time. The server can use Dreamweaver to realize the interaction between database and Java instead of JavaScript and finally complete some operations like preservation and deletion in the process of plotting. It will open the event monitor in the plotting system, extract, identify and store data for users' operation. For example, when clicking the mouse on the map, the system will monitor the coordinate information, and respond to the user combined with the current state.
3. After extracting the operation information, the server uses the map data management tool to process the data that needs to be updated according to certain rules, and get the response data. For example, system can analyze the identifier, the event and the status of the label changed on the map, locate and update the information.
4. After the Ajax engine monitors the changes of the server state, it grabs the data processed by the server, arranges and encodes the data. Finally the data is converted to the string, XML or HTML file identified by the browser.
5. The terminal browser receives the updated data and dynamically responds to the user interface.
6. The HTML files are formed by XML or strings, and then we send them back to the client browser and display in a browser.

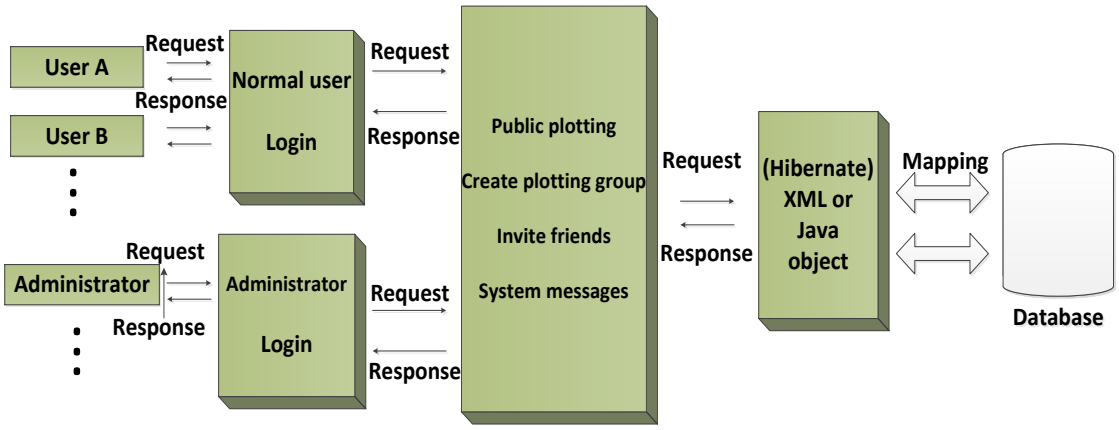

Figure 5. The Flow Chart of User Interaction

The user interaction process:

Firstly, normal users and administrators can use the browser to access the domain on different operating systems, landing page to set digital or question verification, in case of undesigning login.

Secondly, the user sends a login or a registration request to the server. The server responds to the client in a certain rule. When the user is registered, the input data is checked in advance to enhance the user experience effect. For the user's login request, if the server failed to respond in time, it can jump to some public interface and make a landing state response for the user.

Thirdly, after entering the Collaborative Plotting menu, users can create their own label group, or do the plotting task, receive system messages and modify personal information by using the existing plotting group; the creator of the target group has the highest authority on the group operation, such as the inviting of friends, deleting the members, modifying the group information, modifying the contents of the subject, etc. Users can communicate with online friends in real time when adding friends.

Finally, the server firstly set up the XML file or Java object, the content is mapped to the database, in order to form the relation's database table. The system can quickly locate and response as soon as the data is changed.

4. The System Implementation

4.1. The Implementation of Key Modules

The key technologies of Collaborative plotting system model based on Multi-agent[7]. include the construction of hybrid collaborative plotting model based on Multi-Agent, the role access control module based on identity authentication, Collaborative module for multi user operation and Collaborative Plotting conflict resolution module.

4.1.1 Hybrid Collaborative Plotting based on Multi-Agent: Multi-agent system(MAS) is composed of many agents[8]., which members coordinate with each other to complete a task. Its goal is to turn the large and complex system into small, manageable, coordinated system. The activities among the members of the Agent[9]. are autonomous and independent, and their own goals and behaviors are not limited by other agent members, they resolve contradictions and conflicts through negotiation and competition. The research purpose of MAS is to solve the large scale complex problem which is beyond the individual capability of the Agent by using the interactive group consisting of multi agent. The advantages of Multi-Agent system for solving practical problems are the following points:

1. In MAS, the individual Agent is independence and autonomy, which can solve the given sub problem, and it can automatically reason and plan and choose the appropriate strategy, and affect the environment in a certain way;
2. Multi-Agent system supports distributed application, so it has good modularity, easy extensibility and design flexibility. It overcomes the difficulty of building a huge system and the management and expansion caused by massive scale plotting. It can reduce the total cost of the system;
3. In the implementation process of Multi-Agent system, system plotting is based on object-oriented method to construct multi-level, diversified agent, and not to pursue a single large and complex system, the pursuit of its results reduce the complexity of the system and the complexity of the agent problem solving;
4. Multi-Agent system is a coordinated system which is the innovation of the system. Each Agent solves the large scale complex problems through the mutual coordination. The Multi-Agent system is also an integrated system. It uses the information integration technology to integrate the information of subsystems together to complete the integration of complex systems;
5. In the Multi-Agent system, the ability of solving the problem is effectively improved by solving the problem of communication and coordination with each agent in parallel;
6. Multi-agent technology breaks the constraint of AI which only uses one expert system. In MAS environment, experts in various fields may work together to solve a problem that cannot be solved or solved well, thus improving the system's ability to solve problems;
7. Agent is heterogeneous and distributed. They can be different individuals or organizations and developed by different design methods and computer language, thus it may be completely heterogeneous and distributed;
8. The processing is asynchronous. As the Agent is autonomous, each Agent has its own process, and is carried out asynchronously in accordance with its own way.

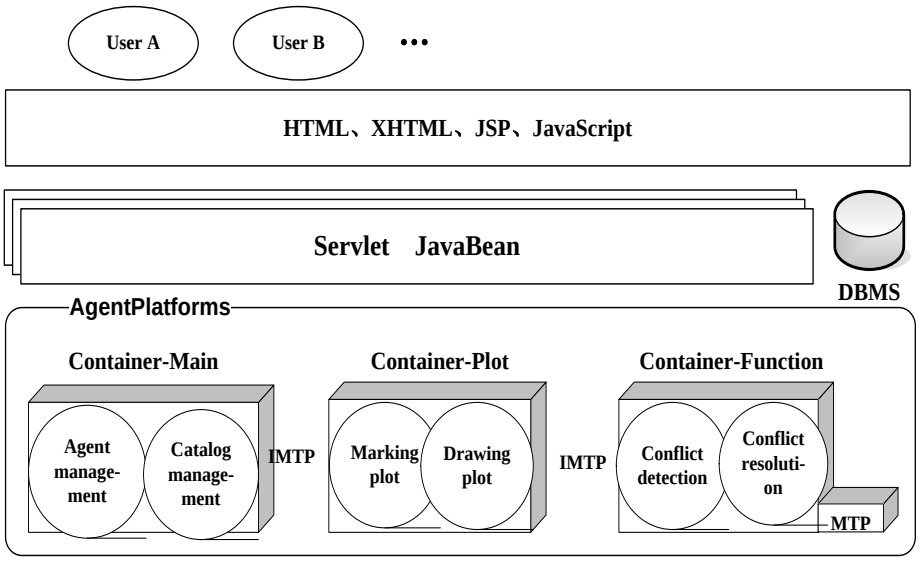

Figure 6. Hybrid Collaborative Plotting Schematic Diagram of Multi-agent

4.1.2 The role access control module based on identity authentication: (1) The Collaborative Plotting System based on multi-agent supports multi user operation. It supports at least one million users' online operation. And ten thousand users can plot online at the same time. After the user plotting on the map, other users can see the information in the shortest time, including images, video, sound and vector icon.

(2)The system will not collapse due to resource depletion, even though there are ten thousand users online at the same time. Multi users can't plot at the same time and in the same place. They should follow the order to plot. The authority will handle it if the plot is wrong.

(3)Users can be grouped to do the collaborative plotting. The plotting between the groups can not be allowed to show for other groups because of the access authority. As it involves resource sharing, the plotting results of the same set are displayed in the terminal, so the group members can see the results.

(4)Before the collaborative plotting, users can be invited to be the group by the leader or they apply to join the group. The module should consider the online real-time operation or not online problem and ensure the real time and security of the data. It must save the message in the database sent by users, the message will be pushed to the client which is convenient for users to process the message in time after the user login the system.

(5)The team leader can make the plotting rules, assign permissions to the members to modify and delete the plotting results. While the ordinary users can only modify their own plotting results rather than others' results.

(6)The group leader has the rights to take operations to the plotting results, such as summarize, add, delete, modify and check. He also can designate two administrators to manage the user information and plotting data of their own group.

(7)The system administrator can take some operations to the plotting information of each plotting group in the system, such as collect, add, delete, modify and search, it also can assign many administrators to handle and filter plotting information.

Figure 7. User Management Interface

4.1.3 Collaborative module for multi user operation and Collaborative Plotting conflict resolution module: The conflict in Collaborative Plotting is a kind of unharmonious state between multiple users. It is the conflict between the multiuses's taking operations in the same place and the same time, or the unreasonable allocation of the non-shared, competing resources. When the management task allocation is not coordinated, it will lead to conflicts produced by

different task in the transmission of information, and the exception occurs when users get information. There are some solutions to these problems:

(1)Make the constraint conditions: users abide by the operation rules to reduce the conflict.

(2)There need to provide sufficient information for the conflict resolution, including user information, geospatial information, the plotting object information, plotting operation information, to ensure adequate and rational use of resources.

(3)As the causes of the conflicts can be predicted, it can be known that when some conflicts occur, it should take some way to develop a program to keep some part of the data and delete other unreasonable data.

(4)Resolve conflicts in consultation. Users on both sides develop a strategy and finally make the solution to resolve the conflict.

(5)Priority selection: Users comply with the principle that 'first come, first operated' during the plotting process, save the database after the completion of the operation. Finally save the correct results through contrast and filter the place-name database and knowledge base.

(6)Administrators resolve conflicts by ruling. When the above ways can't resolve the conflict, the administrator and the team leader jointly act as the adjudicator. When the conflict occurs, they can choice an effective plotting and abandon the conflict plotting. At the same time, they need to know enough information to make the correct judgment, including user information, plotting information, operation type. The adjudicator broadcast the decision to the conflict users and allows it to refresh the information on the local plotting operation interface.

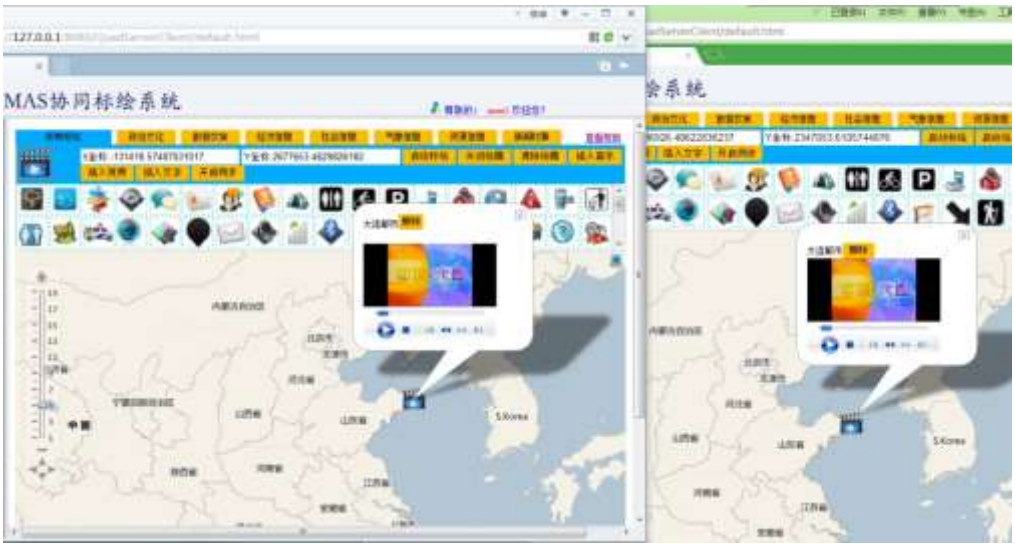

Figure 8. Multi-user Collaborative Operations

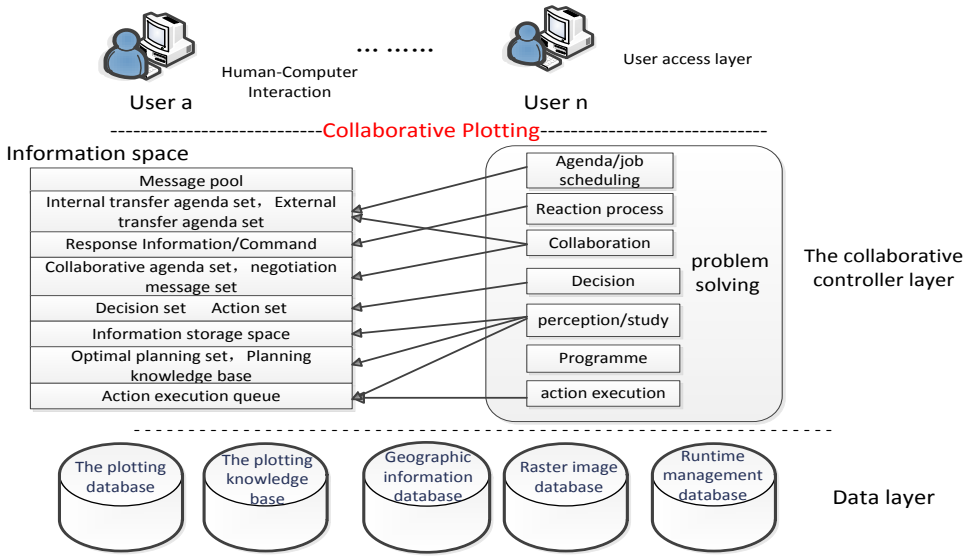

Figure 9. The Principle Diagram of the Collaborative Plotting Conflict Resolution

5. Conclusion

Nowadays many industries have a strong demand for the professional of the spatial information integration and sharing for the application, and technical innovations in the field of Web let people pay more attention to the spatial information network service tools. In this paper, through the design of database, the front-end system design and some key modules, a kind of heterogeneous spatial information [10]. collaborative plotting spatial knowledge system has been realized. Experiments show that the system can realize multi-users' online plotting at the same time, and enhance communication and collaboration between users, meanwhile it has fast response speed and good stability, so it has a certain practical significance.

Acknowledgments

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References

[1] Z.-H. Yan and S. Qiang, "Discussion on cloud GIS", WIT Transactions on Information and Communication Technologies, vol. 57, **(2014)**, pp. 387-394.
[2] S. Schockaert, P. D. Smart and F. A. Twaroch, "Generating approximate region boundaries from heterogeneous spatial information: An evolutionary approach", Information Sciences, vol. 181, no 2, **(2011)**, pp. 257-283.
[3] Z. J. Diao and G. Song, "A research of GIS software application based on cloud computing", Applied Mechanics and Materials, vol. 513-517, **(2014)**, pp. 2107-2110.
[4] W.-D. Li, S.-M. Shumin Peng and J.-Y. Zhou, "Integration framework of multi-source heterogeneous spatial information and remote computing based on web services", 2nd International Conference on Industrial and Information Systems, IIS, **(2010)**.
[5] J. Sawamoto, H. Tsuji and H. Koizumi, "A proposal of multi-agent system development framework for cooperative problem solving and its experimental evaluation", International Journal of High Performance Computing and Networking, vol. 5, no. 1-2, **(2007)**, pp. 34-45.

[6] C. Sombattheera and S. Jun, "Towards optimal service composition upon QoS in agent cooperation", International Journal of Computational Science and Engineering, vol. 8, no. 2, **(2013)**, pp. 119-132.
[7] M. Sifer, F. Dau, H. Hasan, K. Crawford, Y. Peres and Y. Maarek, "Xeena for schema: Creating XML documents with a coordinated grammar tree", International Journal of Computational Science and Engineering, vol. 5, no. 2, **(2010)**, pp. 127-146.
[8] J. Yang, J.-N. Cao, W.-G. Wu and C.-Z. Xu, "Efficient algorithms for fault tolerant mobile agent execution", International Journal of High Performance Computing and Networking, vol. 6, no. 2, **(2009)**, pp. 106-118.
[9] J. Ye and S. Papavassiliou, "An analytical framework for the modelling and evaluation of the mobile agent based distributed network management paradigm", International Journal of High Performance Computing and Networking, vol. 5, no. 4, **(2008)**, pp. 273-284.
[10] H. Wu, C.-Y. He, A.-P. Liao and S. Peng, "A framework for integrating heterogeneous spatial information and applications adaptively based on multi-agent and web service", Proceedings-3rd International Conference on Multimedia Information Networking and Security, MINES, **(2011)**.

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