Database driven Spatial data auditing using QGIS against LDAP authentication and authorization

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Abstract

With the advancement of robust technologies such as web, smart phones and cloud computing, efficient spatial database management system is now considered to be a primary component of a GIS. Spatial database being an integral part of Spatial Data Infrastructure (SDI) or any GIS architecture which acts as a central repository that disseminates data across web and desktop clients. In such scenarios, there is a common requirement for production databases is the ability to track history and authenticity of the data generated: how has the data changed between two dates, who made the changes, and where did they occur? Using the database and the trigger system, it's possible to add history tracking which is a regular practice. But there is a challenge of using desktop GIS tools for editing and validation of the normalized data that is residing in such spatial database keeping data integrity intact with privileged and authenticated users.

Considering the importance of auditing, jurisdiction based user access management and limitation of editing spatial data in a web browser, Nascent Info Technologies Pvt. Ltd has developed Open Source solution based upon LDAP (Light-weight Directory Access Protocol), QGIS (Desktop GIS software), PostgreSQL/PostGIS (Spatial RDBMS), and Multi-corn (LDAP Foreign data wrapper for PostgreSQL) software. Thus, editing and validation of spatial data residing in PostgreSQL/PostGIS takes place using QGIS with authorization and authentication against LDAP where users are given rights.

Keywords: GIS, PostgreSQL, Multi-corn, QGIS, Spatial Data Editing, Validation, OGC

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1. Introduction

In today's world, data remains to be the core part for making decisions. The decisions that are backed up with verified data are the best approach for business governance. The quality of data generated along with analysis and interpretation plays an important role in the outcome. 80% of the data available has spatial component in it. Spatial information is used to visualize analyses and plans and thus to support strategic decision-making. Spatial data is often accessed, manipulated or analyzed through Geographic Information Systems (GIS). Spatial databases provide a strong foundation to accessing, storing and managing spatial data. Spatial database being an integral part of Spatial Data Infrastructure (SDI) or any GIS architecture which acts as a central repository that disseminates and shares data across web and desktop clients. Thus, efficient spatial database management system is now considered to be a primary component of a GIS.

GIS projects worldwide requires a large amount of spatial data for which the collection and production are time consuming and expensive. Spatial data sharing is essential to avoid unnecessary costs from duplicate production procedures. The data quality increases in such data shared environment where many people work on a specific task and try to discover and edit errors within the data. In such scenarios, there is a common requirement for production databases is the ability to track history and authenticity of the data generated: how has the data changed between two dates, who made the changes, and where did they occur? The traditional approach was to make edits locally and then update it on production database. But with the advancement of robust technologies such as web, smart phones and cloud computing, there are ways available for online editing and validation but it lacks powerful topological error correction tools in comparison with desktop GIS clients.

Data normalization is an important step while designing the structure in order to reduce data redundancy and improve data integrity. Using normalization, a database will store different but related types of data in separate logical tables. This leads to joining of multiple tables while querying the data that might have negative impact on performance. The joins can be I/O intensive and might consume excessive amount of time for query execution which might affect the underlying various applications. Besides this, normalization of spatial data leads to difficulties to be edited in desktop GIS clients as it works very well with denormalized data.

There are scenarios that an organization has users for each group or department for accessing various applications that are running on centrally hosted database. The users are usually managed using LDAP. The main benefit of using LDAP is that information for an entire organization can be consolidated into a central repository accessible from anywhere on the network. The centralized database storage leads to the advantages such as data security, data sharing, disaster recovery, reduced maintenance cost etc. Using the database and the trigger system, it's quite possible to add history tracking which is a regular practice. But there is a challenge of using desktop GIS tools for editing and validation of the normalized data that is residing in spatial database keeping data integrity intact with privileged and authenticated users from LDAP.

Considering the importance of auditing, jurisdiction based user access management and limitation of editing spatial data in a web browser, Nascent Info. Technologies Pvt. Ltd. has developed an open source based solution. The solution provides editing and validation of spatial data that is residing in a PostgreSQL/PostGIS using a desktop QGIS with authorization and authentication against LDAP.

The solution contains centrally located database hosting normalized data for the various web based applications. The denormalized data layer comes into the picture to be used in QGIS which is generated from normalized data automatically using triggers. The editing and validation happens through QGIS considering its powerful editing tools as an advantage over web-based editing and validation. While LDAP maintains the privileged user's information with roles like editor and validator. There was a challenge of providing users' privilege information to the

database for accessing the data accordingly. This has been achieved through Foreign Data Wrapper (FDW). The Multicorn plugin for PostgreSQL provides LDAP FDW has been used to access directory server's information via the LDAP protocol. This leads to generation of foreign table in PostgreSQL which maintains the mapping with LDAP. Thus the users performing editing or validation actions using QGIS over the spatial data from PostgreSQL with authorization and authentication against LDAP. The audits are maintained in log tables which provides information on the changes or approval that has been made to the data by the users along with respective date and time.

2. Literature review

Most of the desktop clients do provide the data editing facility based upon shapefile format. Even further some of them provides database driven data editing. Few of them do provide editing and validation but those are COTS software. Hence review was carried out to understand whether such kind of efforts were made either online or desktop level along with their limitations and advantages.

Yaron felus, et al, (2010), described the new approach of the Survey of Israel (SOI) for spatial data consolidation and for map revision. This approach was based on a unique spatial identifier given for every spatial feature in the database. Using this unique identifier, SOI developed an algorithm to create Add, Delete and Update tables. These tables presented an efficient method to store and distribute revisions and updates of the national spatial database to various organizations. The approach also allowed for efficient documentation of past changes and the maintenance of historical spatial data thus created a spatial-temporal framework for databases that includes a time-stamp versioning options.[1]

Xing Lin, et al, (2005), from Inst. of Remote Sensing & Geographic Inf. Syst., Peking Univ., China. found in their study that spatial database management system (SDBMS) plays very important role in efficient data maintenance. Data integrity, quality and security is critical bottleneck of maintaining and creating such databases. Spatial data are complex in nature than any other databases so existing data integrity technologies are insufficient and inadequate for such data. Having integrity ensuring mechanism to SDBMS will bring much convenience to GIS data management department. From this study they derived that a SDBMS supporting spatial integrity constraints has been proved to be much more intelligent and efficient in managing the spatial data.[2]

Frank Hardisty, et al,(2005), College of Earth and Mineral Sciences, The Pennsylvania State University has mentioned in their article on *"*Web editing: opportunities and challenges*"* that there are many advantages of having web as GIS data editing platform such as, individuals with-in an organization who doesn't have gis expertise can carry out web-based data editing with ease. Another advantage is that web application can be tailored according to current expertise of target audience about technology. Along-with advantages there are some potential challenges using this approach. By exposing the dataset for web editing, the database is also exposed to users who doesn't even has access to it. You need to plan for the scenario where a malicious party could corrupt or delete your data. Another challenge is it's possible that well intentioned user can make mistakes and it will affect the integrity of data. There is a need for some mechanism where user is controlled by their respective rights and level of the information user can contribute to. Database maintenance is another big challenge. Over the data editing cycle many copies of same database are distributed and if changes are made in these copies, it should finally have synchronized before the dataset is pushed to the production environment.[3]

Tomas REZNIK and Zdenek HYNEK (2016) developed the web application for managing remote spatial data in crisis situations with the use of Web Feature Service - Transactional (WFS-T). It is a specification of Open Geospatial Consortium that enables client application to

alter the state of feature through insert, update, and delete operations through standard Geography Markup Language. They developed a client software using GeoServer as the mapping server technology and OpenLayers as the client system as a case study for an officer in charge in a crisis situation. This case study has been successfully tested as the part of the crisis management infrastructure for the process of hazardous materials transportation in November 2008. The software developed was helping getting the most up-to-date spatial information from the place of the crisis situation to the headquarters. Communication between the server and the client application was tested through three independent communication channels – direct internet connection to the satellite, wireless internet connection and GPRS. The officer in charge then could draw the areas covered by fire, points representing the position of rescued citizens or line of evacuation route, etc. which was saved in the mapping and database server. At the same time, it could be possible to send additional data from the server to the client application – such as e.g. alternative evacuation route calculated with information from another officer in charge. [4]

Muniru Ayotunde Owoola PhD, GIS Manager, Maltais Geomatics Inc., in his paper-'A Framework for maintaining a multiuser geodatabase: an empirical example', has presented a framework for updating and maintaining multi-user geospatial databases for an electric utility data management. The study mainly emphasises on data maintenance protocols using native software functionalities. In an electric utility network, the collection of data, its updation, retrieval and its usage is critical. The datasets have different characteristics that has to be assessed, updated and maintained continuously in a production environment to support ongoing actions. The study aims at streamlining data management tasks by adopting an enterprise GIS database architecture. The architecture thus prepared, helps in multi-user access, share and edit spatial data subject to DBMS permissions and GIS administration tools through the use of versioning and long transactions. The model supports the physical storage of spatial data inside a DBMS and also supports versioning of data. [5]

Petko Bakalov, et al, (2009), has made network data models to detect the topological errors in the spatial dataset. The network model can be viewed as a graph which depicts the connectivity information about the features in the database. The requirement of these network models is that multiple users should be able to create and update the features simultaneously. Hence, the system provides the editing environment where users can edit the same data at the same time without creating multiple instances of the data. The solution uses the use of multiple versions. A versioned database allows multiple concurrent users to make edits on it without affecting the integrity of the database. Hence, a newly proposed versioning scheme for network models utilizes the dirty areas/objects of the connectivity and rectifies it.[6]

Ming LIAO and Xinlin Qian, in their paper-'A Web-GIS Online Vector Data Editing Method based on Multi-scale representation data structure', puts forward the online data editing method that designs a WindowingQuery for large geometric features along-with SimplifyQuery that controls the vertex scale of geometric features. WindowingQuery is the query method that extracts the geometrical feature according to window. It follows an indexing structure for geometric networks that helps in editing and updating of spatial features with minimal errors. The study includes the use of DBLG-tree indexing as a multi-scale representation data structure to organize vertices of geometric features. [7]

P.A. Woodsford (2007), mentioned importance of the detection of change and the corresponding data update. He further summarised the importance of spatial data quality, especially as data which is from diverse sources used more and more in automated processes and decision-making. He has given emphasis on logical

consistency and discussed some approaches to consistency of content. As per Woodsford, the update processes must be 'data model aware'. He acknowledged the importance of rule based and service oriented architecture mechanisms for update process.[8]

HE Baoguo and ZHU Guobin, in their paper on-'Multi-user Parallel Edit Strategy Based on Version Management' proposed a strategy that offers multi-user parallel edit for spatial data stored inside Oracle database based on ArcSDE version mechanism. Two different modes, online edit pattern and offline pattern, were raised with respect to various environment. A practical application indicates that the two patterns prove their effectiveness although with advantages and disadvantages respectively.[9]

Wu Xi and Huang Yan in their study on-'Based Version-Tree Spatial Data Update' proposes the method of spatial data version updating based on V-tree and controlling the errors raised out of updating by multi-user, multi-affair and offline update. [10]

Method and Materials

Nascent has implemented the solution for its product called CityLayers developed for managing municipal GIS. The product has mainly three components: Departmental geoportal - an Intranet based solution for municipal officials for decision making, data visualization, data analytics etc., Citizen portal - internet based application for public use and property survey mobile application. All the three components access the data from centrally hosted database. LDAP generally is in use where organization has user lists from multiple departments.

The methodology mainly revolves around the database which provides the access and rights to the data besides keeping the track for changes. he methodology mainly divided into following parts:

1. Automated generation of denormalized data layer and its replica from the existing normalized database to be used in QGIS for editing and validation
2. Syncing LDAP users and user access rights with PostgreSQL using Foreign Data Wrapper (FDW).
3. Defining policies for Editing and Validation workflows.
4. Series of Triggers and Procedures for maintaining multiple actions inside the editing and validation workflow.

The database contains spatial and non-spatial tables into respective schemas. For spatial data, spatial inheritance has been implemented to allow storing of homogenous as well as heterogeneous spatial data for querying purpose. Basically child tables store homogeneous data such as point, line and polygon data in respective tables while parent table virtually holds heterogeneous data. Further attribute data is normalized in terms of limiting duplication.
The normalized structure restricts the data editing in QGIS as it accepts the denormalized data structure. To overcome this issue, automated generation of denormalized layers and its replica has been accomplished using triggers. The purpose of generating two denormalized layers is to provide editing on one layer where edits get validated while other layer acts as reference layer for saving the validated edits, which are triggered further to make changes in normalized structure accordingly.

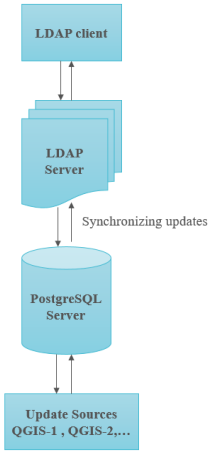

Figure 1 Architecture

Users and their access rights as per jurisdiction boundaries and data pertaining to it are defined at LDAP level. There is a challenge to provide the user and their access right information from LDAP to database for accessing the data from it. Hence, there is a need to sync LDAP users with PostgreSQL database. Here comes the role of Foreign Data Wrapper which enables PostgreSQL server to proxy the information from other data sources. We have used Multicorn Foreign Data Wrapper (FDW) to access any data source in a form of foreign table inside PostgreSQL database.

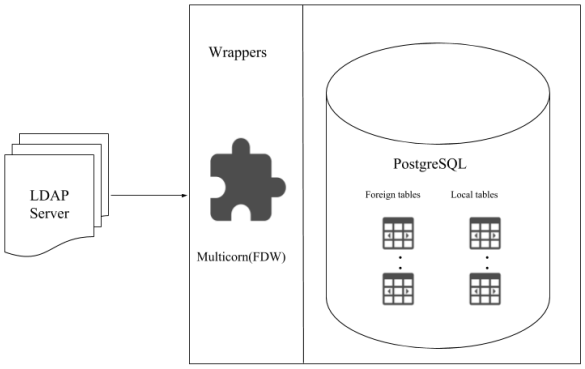

Figure 2 LDAP-PostgreSQL sync. mechanism

The foreign table which is available through Multicorn keeps user mapping with LDAP. The foreign table is read only. There is a mandate to have user to be created at database end to perform editing and validation actions along with enabling row level security. There is a challenge to track the changes happening for user's privileges at LDAP side and accordingly make changes at database end. To overcome this issue, there is a need to create an intermediate table which has mapping with foreign table. The changes happening at LDAP side for users are being tracked through a cron job generation which keeps foreign and intermediate tables in sync with each other.

The tables have row security policies that restrict, on a per-user basis, which rows can be returned by normal queries or inserted, updated, or deleted by data modification commands in addition to the SQL-standard privilege system available through GRANT operation. This feature is known as Row-Level Security (RLS) which has been implemented through use of triggers that runs due to the effect of cron job on intermediate table. Row Level Security Policy feature is available with PostgreSQL version 9.5+.

The policies can be created based on user role as well as column level attributes. Row level security added another level of security for PostgreSQL users. By default, PostgreSQL does not have policy enabled on tables, only super user and privileged users can enable it on table for that user. Hence users with privileges to that table can access all rows for updating or querying.

The benefit of using row level security with editing/validation workflow is that, user can access only portion of the data on which has right to do operations based on AOI. Thus it helps to eliminate unnecessary data error due to lack of knowledge on data inside a different AOI or unauthorized access to particular dataset which is being edited. Further series of triggers and procedures have been implemented for maintaining multiple actions inside the editing and validation workflow

Based on the user access rights and policies defined at database end, the user with editor rights will be able to edit inside a QGIS environment by making a secure connection with the PostgreSQL database and similarly the users with validation rights will validate the same, the resultant of which is reflected inside the database in the back-end. The auditing of data that is being edited or validated is recorded inside a separate log table.

The software used in this study are

1. PostgreSQL+PostGIS(RDBMS)
2. Apache Directory Studio
3. LDAP directory server
4. Quantum-GIS (QGIS) an open source desktop-GIS software.
5. Multicorn(FDW)
6. OS: Ubuntu Linux

3. Results and Findings

In this section, the advantages of database driven spatial auditing using QGIS against LDAP authentication and authorization is discussed along with its workflow. The user's role and privileges which are defined at LDAP can start editing or validation of the data as per their roles using QGIS.

QGIS is an open source cross-platform geographic system application that offers viewing, editing and analysis of geospatial data. The key features of QGIS is that it offers all the available tools for editing of spatial data. It comes with a default plugin of accessing the PostgreSQL database by building a simple connection with it. In this case, connection with database will be against LDAP authentication service that is configured for various users. Upon setting up the connection with PostgreSQL database in QGIS, either editor or validator can access the layers for which it has the rights. These are the layers which are in denormalized structure which are made available based upon the normalized data structure to users by applying row level security. There are four types of policies has been applied while implementing row level security which are as follows: select, insert, update and delete. The data is accessed in QGIS by users is made available through select policy applied for the respective users.

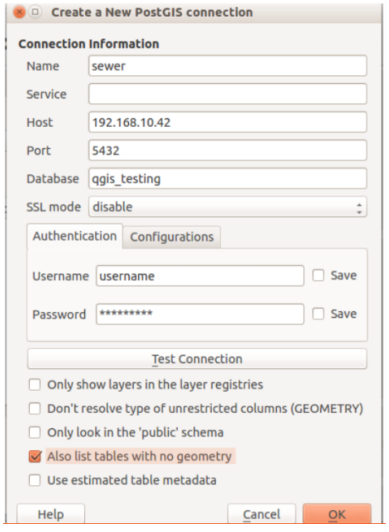

Figure 3 Creating a PostGIS connection

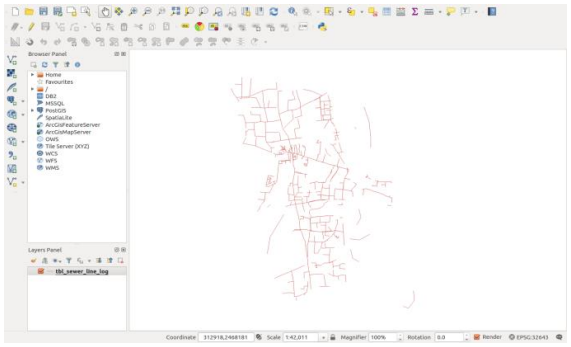

Figure 4 Data Access as per editing rights

Editing of a spatial data includes majorly three types of operations besides merging and splitting.

INSERT - This operation will allow users to insert row-level attributes to the existing data.in a denormalized table i.e. adding a new feature. The features are added inside a table through Insert policy UPDATE - The update operation is the operation done on existing denormalized table. The users will be able to change a single attribute or multiple attributes as well as geometry using update policy DELETE - The delete operation will allow users to delete a particular feature or number of features at a time that is using delete policy.

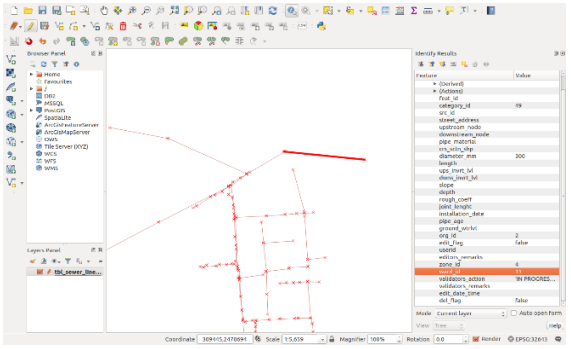

Figure 5 Editor's Feature INSERT action

When editor inserts a record or feature, a new row with geometry and attribute data gets added into the denormalized table. The editor can add his remarks for entering the new feature into the dataset. Upon addition, a flag gets generated which is a notification for validator to understand the entry of new feature along with timestamp. Besides this, the log table also adds the edit entry. The log table maintains the information about username, its action, table name, respective remarks, timestamp etc. When validator starts validating the data who gets the access to denormalized data that has been edited by editor and a reference data which is a copy of existing

normalized data for comparison. The validator thereafter approves or rejects the change that has been made along with remarks. Upon approval, the change that has been made in denormalized data get added into reference data which triggers further to make changes accordingly in the normalized data. Upon rejection, the feature that has been added into denormalized data gets deleted.

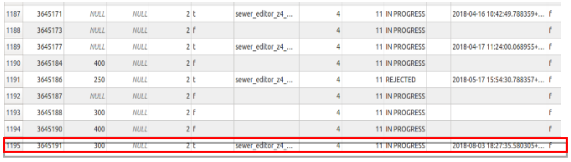

Figure 6 Feature added in log table with editor-details & timestamp

In case of update, there are various scenarios. The editor can either edit attribute data only or spatial data only or both at a time. Here the provision of storing old record and new record in the log table. Upon approval by validator, the edited entry remains unaffected in denormalized data while it gets reflected in reference table which in turn gets reflected in normalized data structure.

For delete scenario, the feature/s that has been deleted by editor from denormalized data get marked by delete flag as notification for validator for deletion. Upon approval by validator, the features get deleted from denormalized data and reference table and finally from normalized data structure. Upon rejection, the record remains as it is in the denormalized data and again ready for editing without making any kind of changes into reference and normalized data.

There are special cases of editing such as merging and splitting related to geometry. In case of merging of the features, the single merged record gets added into the table after deletion of subsequent features which got merged. While in case of splitting, the feature that gets splitted keeps its record into the table but other splitted parts also makes entry into the table.

There was a challenge of handling one to many relationship attribute data further. Following are some of the examples. A single building footprint has many properties and a property has many floors and its measurement details room-wise. A fire station has many types of number of vehicles while a garden has many amenities. In QGIS, such kind of one to many relationship scenario is handled through the feature called relations. This feature allow user to connect feature layer with respective attributes tables with common relation keys between them. After making connection, user can view feature and their underlying data from other attributes tables using QGIS attribute viewer or information tool.

In normalized data structure, one to one relationship between spatial entity and its related attribute data maintained where primary key is for spatial entity. But in case of one to many relationships between attribute data, the relationship is maintained between main attribute table and its associated relation tables where primary key is for main attribute table. The denormalized layer until now used for editing is brought into QGIS along with its associated relation tables for editing one to many attribute relationship data using QGIS relation feature. Similar to earlier approach, the users are given privileges on associated relationship tables using row level security policies mechanism. With this, editor could able to make the edits to the data in associated relation tables as per privileges given.

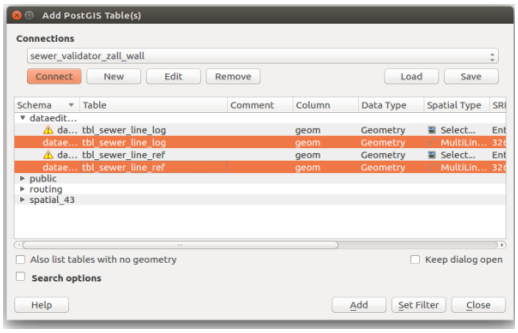

Figure 7 Validator's access to log and reference tables

Upon approval by validator, the record that is edited in relation table is inserted into the reference copy of relation table which further triggered to make final changes into normalized table structure. Upon rejection, the edited entries are removed from associated relation tables.

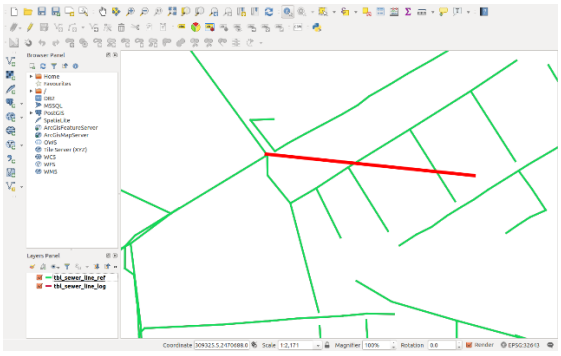

Figure 8 Edited feature difference in log and reference tables

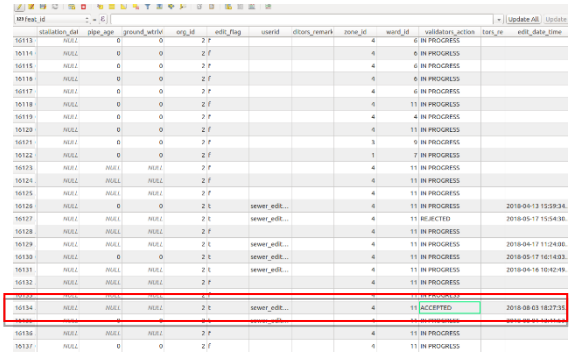

Figure 9 Validator's Action

The advantage of this system is that concurrent users can make edits at the same time on the same feature class with feature-locking facility. If any edit is done on a feature by a particular user, that feature will be locked for other concurrent users for any further edit till the time the previous edit is validated by validator. It prevents multiple editing by users on a single feature. Hence using this editing/validation workflow, spatial data edits/validation can be handled at organization level with data integrity and relative user rights.

4. Discussion & Conclusions

Database driven Spatial data auditing using QGIS against LDAP authentication and authorization solution is the part of CityLayers product. It has been successfully implemented at Vadodara and Bhavnagar municipal corporations (VMC and BMC) in Gujarat, India.

In a municipal corporation, a centralized GIS repository has been hosted for the data needed for all departments. There is department hierarchical structure of users in the corporation which demands for implementation of workflow system even in the case of spatial auditing to track the changes. In such kind of organizations, the user management is mostly handled through LDAP. There is always a requirement that user can access the data of the department to which it belongs. Even in a department only certain users are allowed to make edits to the data which later on gets validated by the authority for final approval.

The traditional way of making edits and approval was tedious and time consuming. The edits made by the GIS Analysts in the local copy that too in shapefile or file gdb format were given for validation. Thereafter validator was validating the data and such final approved data was then uploaded in the database. Regular editing of the datasets by multiple person lead to creation of multiple copies of same dataset that increased confusion of whether which data to be used, the remarks, the date and time of changes made and history of audits and hence, a proper tracking tool was not available to analyze the auditing history of the dataset.

The online editing has become a new trend recently which lacks powerful editing tools and there are constraints of editing large data which affects the performance and transmission of the vector data for editing.

The solution was developed considering the workflow needed for the organizations to ease the data auditing as per the privileges. The editing and validation of spatial data in a desktop GIS environment proves to be more effective and user friendly than online editing due to the availability of advanced editing tools and also in terms of performance criteria.

The users are acquainted with shapefile format like structure and that is the reason to adopt the denormalized layer approach as a solution. With this approach, user does not need to have in depth knowledge of the normalized data structure as most of the one to one relationship tables are made available through denormalized tables which are similar to shapefile structure. For one to many attribute relation tables, there is a need to have knowledge about the relationship. Advantage of using this is that now many level of hierarchical data structure can be easily maintained and other important factor is relationship of each data in different tables is being maintained. Also QGIS editing tools stands out to be outstanding in terms of advanced

editing which makes the use of QGIS more effective than any other desktop GIS environment.

The advantage of using this system is that it is centrally hosted i.e. it has no dependency on machine. Role-based access rights lead to proper authorization of data. LDAP authentication is useful for centrally managed single sign in system and also leads to enhancing database-level security. The system also logs the session hence improving the auditing and history tracking capabilities.

The disadvantage is that notifications are not available at QGIS side that has been generated from database side. The other minor disadvantage is that the user has to have little knowledge on relationship between attribute tables in case of one to many relationships.

With the use of row level security policies, multicorn extension for foreign data wrapper for LDAP and thorough use of stored procedures and trigger functions made the solution robust and secure. We have implemented this solution on various flavours of linux such as Ubuntu, Suse, RHEL and even on Windows Server. Thus, the solution that has been provided and implemented is cross platform.

The desktop GIS which has the capability to establish connection with PostgreSQL database and allow PostGIS based layer loading, editing etc can work with the given solution. Currently QGIS has been used as a desktop client and in future there is a plan for integrating the solutions with other open source desktop clients.

5. Conclusion

The database driven spatial auditing using QGIS against LDAP authentication and authorization is the part of CityLayers product which provides the complete solution for the municipal GIS requirements of a corporation. The “out of the box” solution provides an upper hand in handling database driven spatial auditing by integrating with LDAP which centrally manages user and their rights. Hence, for the first time, considering Digital India policy, an effort has been made in the open source geospatial domain to provide a simplified OGC compliant solution for spatial data edits and validation along with auditing.

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7. REFERENCES

[1] H. S. Y. T. Yaron Felus, "GIS Versioning Management - The Approach of the survey of Israel," *ISPRS Archive Vol.XXXVIII,Part 4-8-2-W9, "Core Spatial Databases - Updating, Maintainance and Services - from Theory to Practice,* 2010.

[2] Y. Z. L. G. Xing Lin, "Spatial data integrity ensuring mechanism in SDBMS," in *IEEE International Geoscience and Remote Sensing Symposium*, 2005.

[3] F. Hardisty, "Web editing: oppurtunities and challenges," *Cloud and Server GIS, GEOG 865,* 2005.

[4] Z. H. Tomas Reznik, "Data Management in Crisis Situations through WFS-T client," in *Proceedings of Cartography and Geoinformaticsfor Early Warning and Emergency Management* , Prague, 2009.

[5] M. A. O. PhD, "A Framework for maintaining a Multiuser Geodatabase: An Emprical Example," in *ISPRS - Vol.XXXV*.

[6] E. H. S. M. V. J. T. Petko Bakalov, "Versioning of Network models in a Multiuser environment," in *Advances in Spatial and Temporal Databases*, Denmark, Springer, 2009.

[7] X. Q. Ming Liao, "A Web-GIS Online Vector Data Editing Method based on Multi-scale Representation Data Structure," *Technical gazette, Vol. 25 ,* p. 171, 2018.

[8] P.A.Woodsford, "Spatial Database Update and Validation - Current Advances in Theory and Technology," in *ISPRS*.

[9] Z. G. HE Baoguo, "Multi-user Parallel Edit Strategy Based on Version Management," *Geospatial Information,* 2007.

[10] H. Y. Wu Xi, "Based Version-tree Spatial Data Update," *Urban Geotechnical Inverstigation & Surveying,* 2011.

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