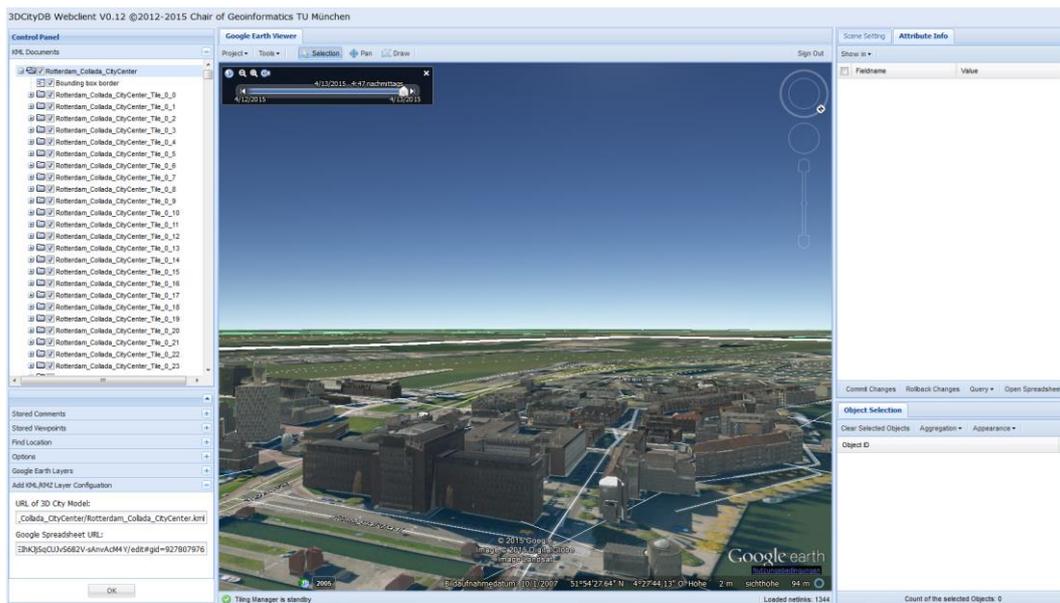
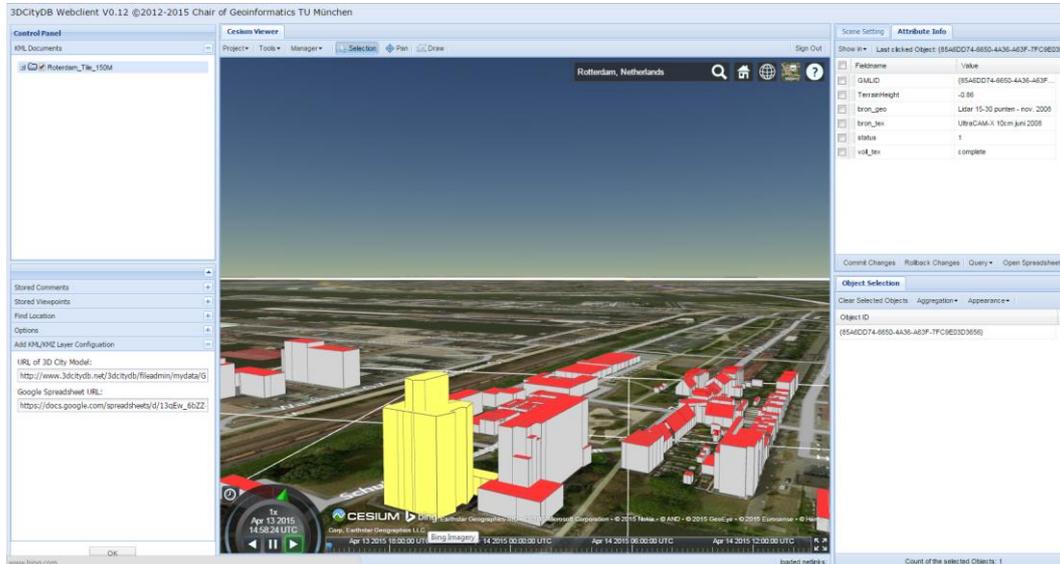




Cloud-based 3D Web Client based on 3D City Database



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How did you implement the client?

The web based 3D client has been developed to serve as a user interface to end users performing functions such as interactive 3D visualization and exploration of large scale 3D city models. It is a static application based on the ExtJS JavaScript-based web framework and can be deployed via any web server like Apache or even Dropbox without the need of an application server. This 3D web client supports both the Google Earth plugin and Cesium acting as the visualization engine which enable to visualize the graphical representation of the 3D city models. While the first version of the 3D web client requires installation of the Google Earth plugin locally, the current version is using Cesium Virtual Globe which is an Open Source JavaScript package supporting the presentation of 3D contents within the web browser where users can dynamically switch between 3D globe visualization and 2D map projection. It utilizes HTML5 and WebGL to provide hardware acceleration and plugin independence and provides cross-platform and cross-browser functionality. Furthermore, user can control the dynamic elements of 3D building models using JavaScript commands embedded within Cesium JavaScript API. However, the current version of Cesium supports reading and displaying of pre-styled 3D models in KML format. In order to visualize large 3D city models, we have extended Cesium to support KML network links, caching, dynamic loading and unloading of tiles, and 3D object highlighting.

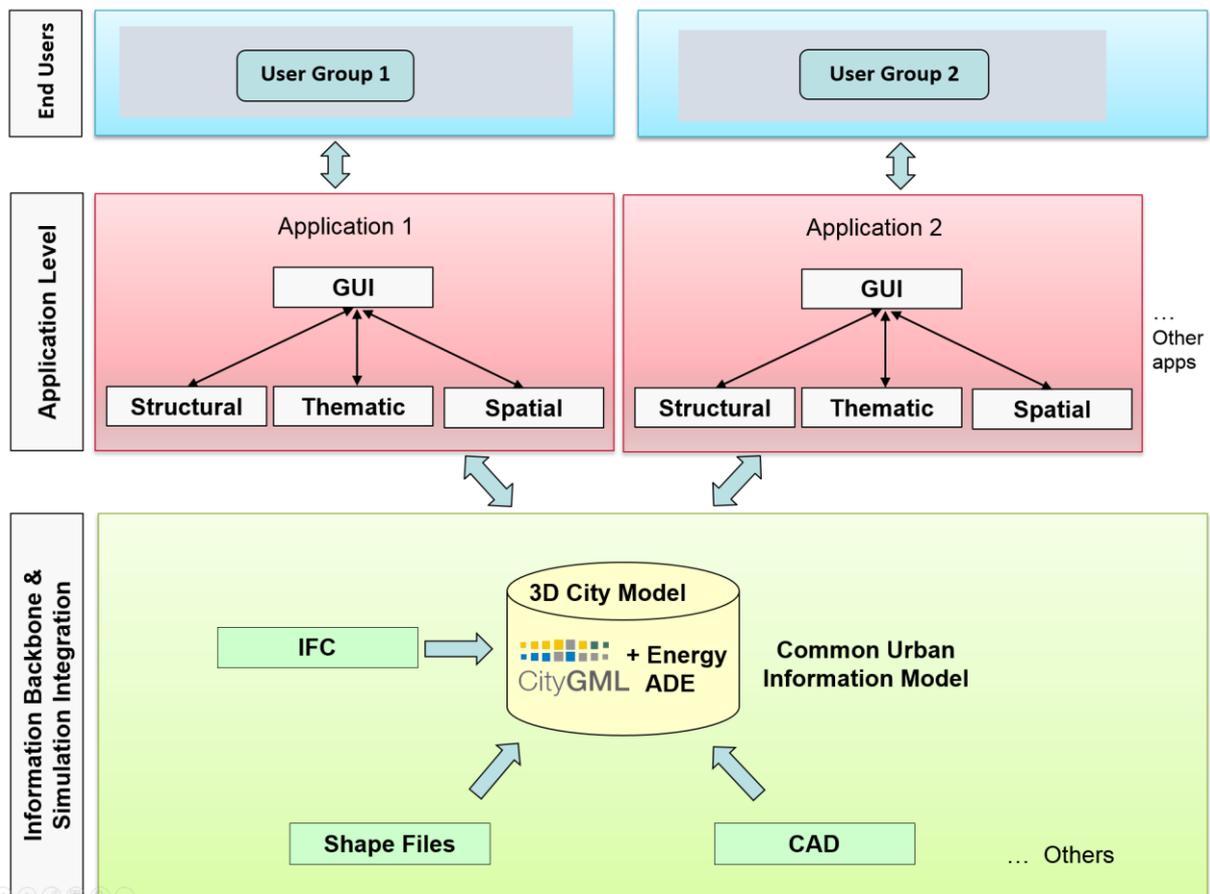


Figure : Multi-level architecture for the 3D web client



How do you transfer the data from the server to the client?

The CityGML data on the server side is stored within the open source geodatabase called 3DCityDB Version 3.0.0 (<http://www.3dcitydb.org/>). It consists of a set of SQL scripts which allow to create relational database schema for efficient management and maintenance of large CityGML datasets. It provides a Java frontend application named 3DCityDB Importer/Exporter which allows for high performance importing and exporting CityGML dataset with arbitrary file size. It also allows to export the contents in the form of KML/COLLADA format allowing it to be viewed and interactively explored in the 3D web client. The functionalities of the Importer/Exporter tool can further be extended in a modular way by installation of plugins, adding specific abilities to interact with the 3DCityDB. For instance, by using the Spreadsheet Generator Plugin, the arbitrary subsets of the city model data can be exported in tabular form having the selected attributes from 3D city database instance either as a CSV/XLSX file or directly be uploaded as a Google Spreadsheet Document using the corresponding Google Cloud Service (Google Docs). As a web-based frontend user interface of the 3DCityDB, the 3D web client logically links the 3D visualization models in KML/COLLADA format and the table data stored in Google Spreadsheet and allows viewing, editing, and querying objects and their thematic data.

Do you support tiling scheme?

Yes – our approach supports tiling scheme. The 3DCityDB allows to generate the KML/COLLADA files from CityGML based on different tiles. These tiles can be manually or automatically created based on the entire bounding box which results in creation of one master KML file pointing to all tiled export contents. Furthermore, the tiling manager in the web client has been developed to support the tiling of large 3D city models and dynamic loading of the tiles. The web client has been implemented on top of the Cesium virtual globe to process and visualize the large 3D city models with different level of details. Utilizing multi-threading capabilities of HTML5, the time-costly operations such as parsing of multiple 3D objects are delegated to a background thread running in parallel. At the same time, another thread monitors the interactions with the virtual camera and takes care of loading and unloading the data tiles according to their visibility. Additionally, our approach also supports caching mechanism, allowing the results from an earlier computation to be stored in a cache. It allows to read the data from the cache, which is faster than re-computing an entire result. In our implementation, the size of each tile is approximately 150 meters. Our approach does not support hierarchical tiling.

Please give a short description of streaming protocol.

For streaming 3D city model, we simply use the Hypertext Transfer Protocol (HTTP) to fetch the KML/KMZ files from the server without using any specific interface like WMS, WFS etc. The 3D web client utilizes the Cesium JavaScript framework on the top of HTML5 which allows for performing Ajax requests to access remote data hosted in a cross domain. This mechanism is so-called Cross-Origin Resource Sharing (CORS). In order to enable CORS the web server hosting the 3D city model should be configured properly to support CORS according to the client-domain. Fortunately, the popular cloud-based server like Dropbox has already enabled CORS headers so that the 3D web client can very easily make a cross-origin request directly to Dropbox, without the need to use proxy or JSONP Strategy.



Which browser (version) did you use to test the application?

The current version of the web client works successfully on multiple platforms including Windows 7, Mac OS X and Linux. In future, the web client will be functional on mobile platforms such as iOS and Android. The client has been tested on latest versions of following WebGL capable browsers:

- Google Chrome
- Mozilla Firefox
- Opera

Did you include some special data sources/ special features you would like to highlight?

- Large data exploration – With the help of the implemented tiling manager, the web client allows efficient data exploration of large scale city models (>500000 buildings) on the web browsers.
- Rich user interaction with different aggregation levels – The web client supports highlighting of the city objects on mouse over and mouse click. Furthermore, it supports interaction with nested structures of the CityGML objects, e.g., buildings consisting of walls and roof surfaces. Besides the visualization model, the web client also allows to display extra structure information and thematic information from the CityGML data repository. To achieve the same, not only a visualization model (in KML/COLLADA) is exported, but also additional JSON encoded data about the decomposition of all complex city objects like buildings and thematic information in the tabular form are also exported. This is then exploited by the web client to expose the different aggregation levels to the user, resulting in a better user interaction with complex structured 3D city models as supported by CityGML.
- Query and analysis - The city objects can be queried on the basis of their attributes. Furthermore, for a group of selected city objects, aggregation functions such as sums, averages, minimum, or maximum values of numeric attributes can be calculated directly in the 3D web client, and results are displayed in the attribute list and the resulting objects are highlighted. The property information of the selected city objects may include thematic information which can further be exported in an HTML table as a report. With the presented functionality, the application range of the 3D Web client varies from the pure visualization of 3D geometries to the exploration of attribute data of the 3D City models in the form of tables to the calculation of results of complex analysis and simulation of the semantic city models.
- Google spreadsheets can also be used as a lightweight calculation engine by including formulas. Based on the 3D web client, we have realized an application for the assessment of building heat energy demand and retrofitting potentials.
- Users can interactively and collaboratively edit thematic attributes stored in the Google spreadsheets. Users can also add their own thematic attributes to the city model.
- Configuration data is also stored in a Google spreadsheet.
- Spatial bookmarks with camera perspective and user comments can be stored and collaboratively shared.

Links to the website of your contribution

<http://www.3dcitydb.net/3dcitydb/fileadmin/3DWebClient/index.html>