CREATING CONTEXTUAL VIEW OF CMMS ASSETS USING GEOSPATIAL 2D/3D DATA

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ABSTRACT:

Computerized maintenance management systems (CMMS) aim to assist administration and maintenance agents in their asset maintenance tasks (e.g., building, network, air conditioning, faucets maintenance). In this context, geospatial data can help to have a better understanding of the assets they represent by providing additional information: spatial, thematic, temporal, or inter-object relationships. Using such information often leads to interoperability issues as different domains describe them with different data models, like Building Information Modeling (using the Industry Foundation Classes format) and Geographic Information System (using the CityGML format). Spatial information, and particularly 2D or 3D geometry, are stored using heterogeneous representations (e.g., triangle soup, boundary representation, sweep volume, composite solids). Visualization and navigation in the information provided by multiple data sources remain a problem, as there is a need to understand the domains, languages, and models used to describe them. Furthermore, there is a need for solutions to integrate geometric data to manage and visualize existing 2D or 3D representations of assets in geospatial data stores while being able to retrieve additional information using semantic data stores. We propose, in this paper, a methodology to integrate heterogeneous geospatial data in the same viewer by transforming geometric data to a standardized format while keeping a link to sources, in order to navigate in the context of an asset by visualizing its spatial and thematic information.

1. INTRODUCTION

Computerized maintenance management systems (**CMMS**) are intended to help administration managers make informed decisions and to assist maintenance workers in their activities. A better understanding of **the many objects to be managed and maintained** (such as a building, a water system, a faucet, etc.), referred to as **assets** in this article, would contribute to these tasks. This can be achieved by integrating the context of an asset, i.e. combining data from heterogeneous sources to provide users a unified view to help to understand it (what it is: physically, functionally and operationally, its lifecycle, its location, etc.) in its environment (spatial and/or functional). Exploring the relationships with other objects in its environment may help to enrich the **context** of an asset. It could help understand the system they are part of and the role of the asset in it. For example, by finding all the pipes connected to a faucet, it is possible to reconstruct the water network. It could help locating an asset by using topological relationship with other objects. For example by providing the information that an asset is in a specific room in a building.

As more data become available, using the relevant data that can provide more information about assets may help to better understand them. For example, the integration of **Geographic Information Systems** (**GIS**), used to capture, store, analyse and display geospatial data, with CMMS (McKibben and Davis, 2002), using a Web viewer has proven that geospatial data can contribute towards this goal: for example, the use of spatial information allows an asset manager to easily locate assets scattered over a large area and understand its topology.

Geospatial data aims to describe **features**, abstractions of a real world phenomena, by providing spatial (such as location, topology and geometry), thematic (such as textual description, relationships with other features, etc.) and temporal information. They have their own sources and exist in their own well-developed environments, such as : **Computer-Aided Design** (**CAD**) that aims to assist in the design, layout and technical documentation of object, **Building Information Modeling** (**BIM**) that allows the creation of digital representation of physical, operational and functional information of a facility (building, bridge, tunnel, etc.), as well as GIS. They may follow different standard formats, for instance : CityGML or GeoJSON for GIS, Ifc for BIM, or DXF for CAD. Natively built for their respective environments, the use of such multi-source and heterogeneous data naturally leads to interoperability problems. Moreover, understanding their data construction philosophy, modelling design (if it exists), and usages are es-

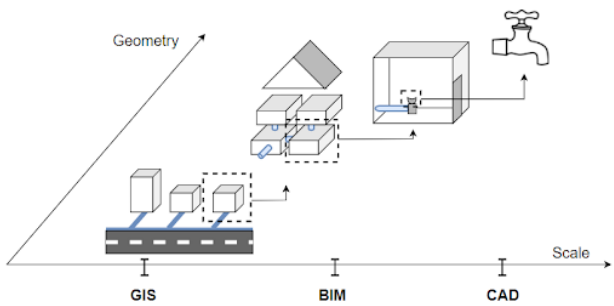

Figure 1. Possible representation of CMMS assets from geospatial data

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sential to use these data together.

Furthermore, geospatial data models describe features at different scales, with more or less detail, as shown in Figure 1: city scale, building scale, object scale. Thus, they can provide different information about the same feature. Therefore, it must be possible to navigate between those scales and gather information found in geospatial data to help understand an asset using its context:

- Spatial information may help to better understand an asset: for example, it is easier to apprehend the topology of a building water network using 3D geometry because it allows visualizing the network through different floors.
- Thematic information could enrich the existing description of an asset in a CMMS software.
- Temporal information helps describing the life cycle of an asset, using its evolution through time and space.
- Using data models representing assets at different scales (at city scale, building scale, asset scale ...) could help by delivering various views on an asset.

Achieving navigation in this information requires solving a more general problem: the integration of heterogeneous geospatial data. As mentioned previously, geospatial data can offer different information about a feature: spatial, thematic, temporal, or relationship with other features. As this information can be stored using different languages and data models, there is a need for a solution to integrate such heterogeneous data, no matter their data sources, whether they are semantic or geometric. Therefore, we propose a solution to integrate both semantic and geometric information of an asset and its context from a data source. This integration allows users to navigate in this information in the same view, on the Web. This solution aims to be as generic as possible to gather information from heterogeneous data sources.

We focus on integrating the geometric data provided by the various geospatial data sources in this paper. Indeed, geospatial data models often do not describe geometry in a visualization friendly way. They were created for the purpose of storing and sharing this information: for example, geometry can be stored using heterogeneous representation (triangle soup, boundary representation, sweep volume, composite solids, etc.), even in the same data model. Some need pre-computation for visualization modern viewer, and some visualization problems are not handled, such as spatial organization of the objects.

In this paper, we propose a methodology and a logical architecture to integrate the geometric data of various geospatial data in the same Web viewer, by extracting and converting it into a unified and standardized model while keeping a link to its sources, to retrieve semantic data if needed. This work aims to help the user achieve a better understanding of assets to manage by making it possible to create contextual views of an asset by navigating in the spatial and thematic representations brought by heterogenous geospatial data. Another underlying difficulty of this work is the need to understand and align the different concepts brought by each **domain** (**GIS**, **BIM**, **CAD**) to visualize them efficiently in the same viewer. Our approach makes use of generic components and standards as a set of services as a reproducible solution, since it is intended to be implemented and demonstrated in existing **CMMS** software [1].

The paper is organized as follows: in section 2, we present some standardized geospatial data models, as well as works related to the visualization and integration of these data. The proposed methodology to integrate the 2D/3D geometry of geospatial data is detailed in section 3, while its implementation is described in section 4. The obtained results are then presented and discussed. Finally, section 5 concludes this paper by presenting our future course of action.

2. RELATED WORK

Geospatial data can offer numerous details about features that can be thematic, temporal, or spatial. Mobilizing this information, such as 3D geometry, can help to achieve a better understanding of CMMS assets. For example, (Verghote et al., 2019) showed that visualizing objects in 3D helps to understand the indoor routing of a building. There is also a need to take into consideration to the way this information is presented. Indeed, (Neuville et al., 2019) showed that to help the user understand 3D geometry, the chosen point of view for visualizing the geometry plays a significant role in its comprehension. Mobilizing multiple features of the same object, especially in the same environment, is a challenge that many researchers and developers are trying to solve. They can represent the same object at different scales, through different domains: city-scale (for example, 2D and 3D GIS), building scale (e.g., BIM and object scale), and object scale (e.g., CAD diagrams). Each domain has its standard, like Ifc for BIM, CityGML, or GeoJSON for GIS.

The Open Geospatial Consortium (OGC) has defined several open Web Services to access and visualize GIS data. The two main existing services are the Web Feature Services (WFS)[2] and the Web Map Services (WMS)[3] . These standardized services provide direct or rasterized access to normalized geometry of features, defined by the OGC as the starting point for geographic information modeling and as the abstraction of real-world phenomenon. These services are useful to describe and visualize 2D geometry, that can be stored as polygon, polyline, point, image ...

To represent 3D geospatial content, the OGC and Khronos also defined the 3DTiles[4] standard "designed for streaming and rendering massive 3D geospatial content". The 3DTiles standards allows to share, visualize, and interact with massive heterogeneous 3D geospatial content across desktop, web, and mobile applications. This standard aims to descaribe and visualize 2D and 3D triangulated geometry, stored using the GLTF[5] format, or point clouds on the web.

We decided to use these standards as they are commonly used to represent 2D and 3D geometry from spatial data on the web. Using these standards, some researchers focused on visualizing city objects by making use of CityGML data. For example,

[1] CarlSource, developed by CarlSoftware

[2] http://docs.opengeospatial.org/is/09-025r2/09-025r2.html; online accessed April 20, 2022

[3] https://portal.ogc.org/files/?artifact_id=14416; online accessed April 20, 2022

[4] http://docs.opengeospatial.org/cs/18-053r2/18-053r2.html; online accessed April 20, 2022

[5] https://www.khronos.org/registry/glTF/specs/2.0/glTF-2.0.pdf;online accessed April 20, 2022

(Gaillard et al., 2015) proposed visualizing CityGML data on the web by creating 3DTiles, allowing the user to navigate through a city in a 3D environment. One interesting part of this approach is that they succeeded in keeping a link between a CityGML object and its 3D representation in the 3DTiles, i.e., making it possible to visualize geometric and thematic information of a building on the same context. This feature may help to understand a city object by completing geometric information with thematic one. Following the same approach, (Jaillot et al., 2020) proposed a solution to detect changes in the city between various periods using CityGML and store them using an extension of 3DTiles [6], allowing the user to navigate through a city in 4D, through time.

Other works focused on building data visualization by converting Ifc files into 3DTiles. (Chen et al., 2018) proposed a solution using open source tools. However, this solution creates only one geometry for a whole Ifc file and does not allow retrieval of the associated semantic data. The solution of (Xu et al., 2020) allows for the creation of one geometry per Ifc object and keeps the associated semantics directly in the generated 3DTiles. Nevertheless, the link to the original Ifc instance is lost; storing semantic data in a 3DTiles file next to the geometry implies either enlarging the 3DTiles file size, making it longer to load in a web solution, or losing information to avoid this drawback. Some works focused on extracting new information from building data that may help CMMS agents. For example, (Lin et al., 2013) and (Khan et al., 2015) worked on producing indoor routing using BIM data.

In their literature review, (Fosu et al., 2015) classify approaches of the use of BIM and GIS data in five categories: BIM to GIS conversion (Stouffs et al., 2018), GIS to BIM conversion (Donkers, 2013), BIM-GIS integration (Karan et al., 2016, Hor et al., 2016, Huang et al., 2020), Unified Building Model (a data model able to represent objects that can be found in BIM and GIS) (El-Mekawy et al., 2012, Yan et al., 2021). The last category is the use of a Web Viewer to use this data, like (Hijazi et al., 2020) done by using 3DcityDB (Yao et al., 2018) and BimServer (Beetz et al., 2010) to transform the geometry as GLTF, that allows users to directly query the geometry they need to visualize in databases. BIM-GIS conversion or integration implies different challenges (Zhu et al., 2018) that still needs to be solved:

- **at the geometrical level**: with the storage of geometry, geo-referencing and LOD harmonization
- **at the semantic level**: since BIM and GIS models were designed for different purposes, major differences exist between them(Fosu et al., 2015).

Finally, considering IFC and CityGML data as the most used models currently, there is a need for a solution to visualize and navigate heterogeneous geospatial data from the city to building interiors. These data offer different representations of CMMS assets, and thus bring different key information about them. In order to visualize them, using standards such as WMS/WFS and 3DTiles seems to be mandatory if we want to propose a reproducible, usable, and interoperable solution for all. We will focus on using data directly from their sources as our purpose is to let data evolve in their own domains and gather information about an asset only when it is needed.

[6] https://github.com/CesiumGS/3d-tiles/tree/main/extensions;online accessed April 20, 2022

3. CONTEXTUAL VIEW OF AN ASSET

Our goal is to provide contextual views of an asset to the users, thus allowing them to visualize the many features in geospatial data describing CMMS assets. To this end, we propose a solution to visualize and navigate heterogeneous geospatial data on the web by reading and extracting geometric information from this data. Moreover, this solution ensures that the extracted geometric information is always linked to its sources for retrieving additional information using semantic data. By doing so, we ensure that the users can access all information, geometric and semantic, of an asset from geospatial data.

A contextual view is the visualization of one or more representations of an asset and its context. We can distinguish **two types of representations**. The first, **spatial**, represents the **location**, the **topological** or geometric **information**. This representation can be either **realistic** or **symbolic**, such as an icon, in 2D or 3D. For example, when a user does not need a realistic and detailed visual representation of an asset and only needs to find its location, its topology, or the surrounding objects, a symbolic representation, would be sufficient. For example, a church is often represented as a cross on a 2D map. The second type of representation, **thematic**, represents textual information, using forms, official and technical documents.

Offering contextual views of an asset could help either asset managers or maintenance workers by enriching the available information about an asset to help understand it. For example, a plumber may need various types of information from different sources : the 3D view of an indoor water network to understand its topology (BIM), but also the position of the building in the city water network (SIG). They may need additional semantic data, like the flow rate of a specific pipe (BIM) or its maintenance history (CMMS).

We propose a methodology and a logical architecture to navigate in various representations of assets stored in geospatial data and create contextual views from them. The **logical architecture** of our methodology is presented in Figure 2. We represent georeferenced semantic data objects that can be stored in databases or files (Figure 2, left). They can be either geospatial or CMMS data. They are divided into two categories: those that have 2D or 3D geometrical information and those that do not. The main idea behind this division is that if a non-spatial object, such as an event (e.g work order, disorder ...) or a document (e.g technical documentation, photograph) does not have a spatial representation, or if one data object of an asset is only thematic, it is not visible in a 2D or 3D environment. For example, work orders need to be visible on the map to allow administrators to understand the current status of their asset fleet. Since they are not physical objects, they are not described by geometry but by a spatial representation is needed to locate them. By linking non-spatial objects to their linked asset or by linking a thematic representation of an asset to a geospatial one, we ensure that they can be accessed. Since we want to gather as much information as possible, we will try to understand each of the data sources to preserve the original information. The thematic data must be accessed directly from the data sources, using specific APIs for each source (the red plain lines on the left). The use of APIs allows us to obtain a solution where each component is autonomous and weakly linked to the others, making it easier to try and use multiple solutions for each component.

We first propose to extract and transform geometry data to a standardized homogeneous format (Figure 2, right). In doing

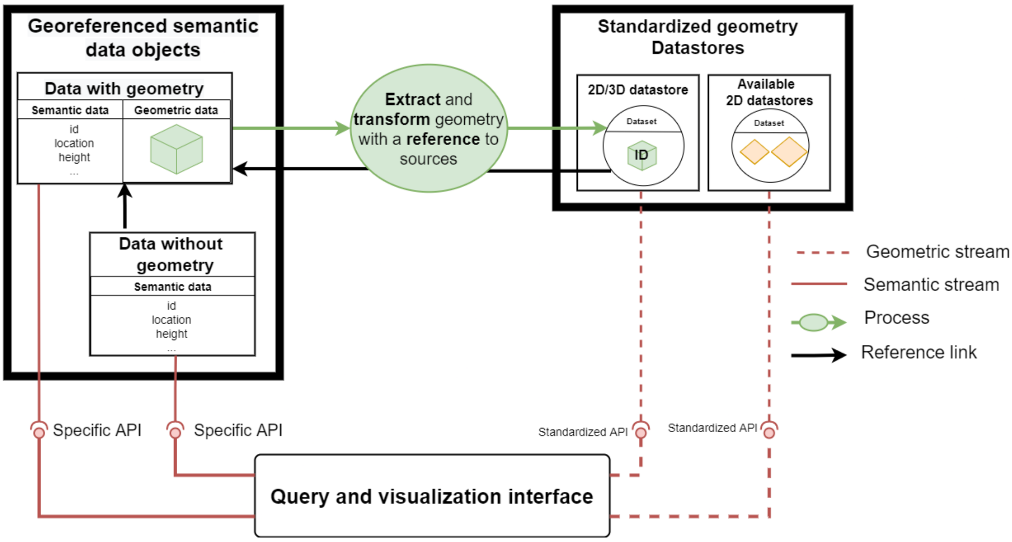

Figure 2. Logical architecture

so, we ensure that all geometry are stored and organized in the same way. This ensures that the viewer can read all geometric data, regardless of its original model. In addition, using a standardized geometry model solves a variety of problems related to visualizing geometry on the Web, such as spatial organization, geometry definition, and the number of objects to display that the geospatial model does not address. We need to make sure that the chosen standard handles geospatial (implicitly georeferenced) data correctly, to facilitate its visualization and to solve problems such as projection system manipulation.

When extracting and transforming the geometry (Figure 2, green arrow), a link to the original sources must be kept to access more information about the visualized objects. For example, once the BIM spatial representation of a building is being visualized, the user may want to gather additional information from the BIM thematic representation, like the flow rate of a pipe or to find other pipes that are connected to it. By providing a link between a spatial representation and its original data sources, the viewer requesting and displaying the data will know where to find the semantic data related to the spatial representation. Providing a link between an asset and its various representations described in multiple data sources allows one to navigate in its context by having multiple spatial and thematic representations using both geometric and semantic data. This can help in better understanding of an asset by using complementary information that exists in different domains.

As data may come from heterogeneous sources, they can evolve on their own. They can be used and modified by many other people. They can exist in different databases. As we want to be able to display all geometric data, we propose to convert them to a homogeneous standard, to let any kind of viewer use them while supporting only one standard. At this point, we then have another representation of the geometric information available in addition to the source representation. That is why we chose to keep the link between a geometry and its semantic data, so that it is possible to retrieve any kind of information on an object brought by the same source. As a geospatial dataset may describe many objects, each created geometry must correspond to an object. The link is not simply between a geospatial dataset and the geometry created from it. A link is created for each described object between its geometry and source, using its identifier (for example, GUID for Ifc and GMLID for CityGML) in the source. As keeping just the identifiers may lead to problems such as two objects from two sources having the same identifier, we also keep a reference to the source in the link. Additionally, as we want to use geospatial dataset without modifying them, the link must then be stored in the geometry. The homogeneous format used to store geometry must allow us to do so.

As we wish to propose the user to create a contextual view of an asset using semantic and geometric data, there is a need for a Web viewer to be able to navigate all those heterogeneous data in one scene. It must also let the user interact with an asset in the same way as it does in a classic CMMS software. For example, the user must be able to declare a disorder, or assign a work order. Using the link between the geometry and semantic data allows to navigate in all information brought by a single source. Using the link between data with and without geometry allows to navigate between many semantic information about the same object, from its spatial representation.

4. ARCHITECTURE AND RESULTS

4.1 Technical Architecture

S.No.	Name	Repository
1.	UD-Viz	`https://github.com/VCityTeam/UD-Viz`
2.	Py3DTilers	`https://github.com/VCityTeam/py3dtilers`
3.	3DCityDB	`https://github.com/3dcitydb/3dcitydb`
4.	BimServer	`https://github.com/opensourceBIM/BIMserver`
5.	Geoserver	`https://geoserver.org/`

Table 1. Repositories of the open-source components proposed

Figure 3 shows a technical architecture that allows multiple geospatial data to be visualized in the same viewer using the presented logical architecture. The current implemented solution can handle several types of data: GIS with GeoJSON or CityGML, BIM with Ifc, various 3D object representations with point clouds or .obj file, CMMS with its database that handles

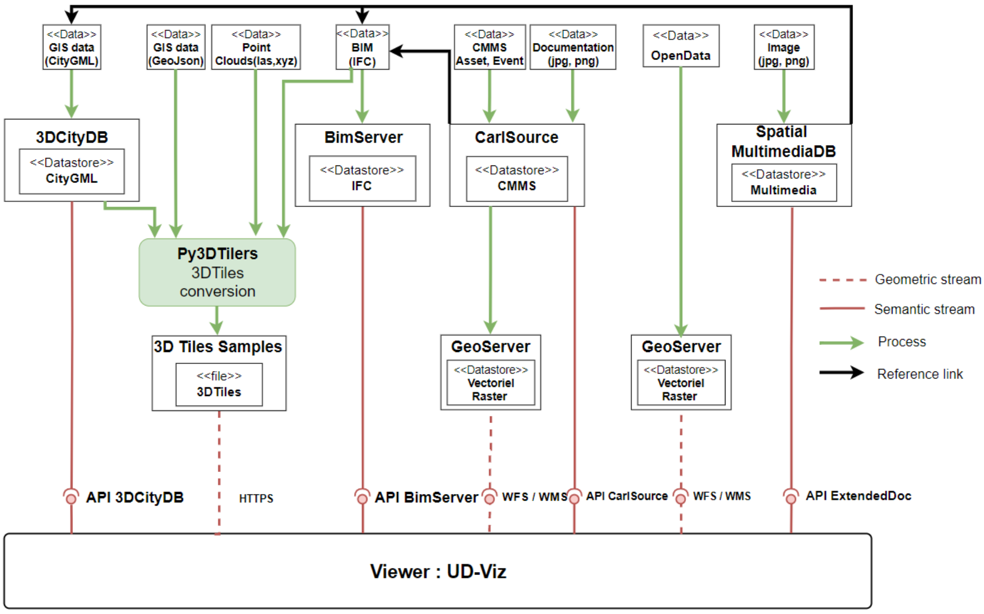

Figure 3. Technical architecture

assets or events and associated documentation. Additional multimedia representations are stored following the work of (Jaillot, 2020) with a Spatial MultimediaDB, which provides additional geospatial information position multimedia in a 3D environment. We propose open-source components as much as possible, to make our solution available for use by the community. The list and references to the open-source components used are described in Table 1. This technical architecture answers a need to visualize other representations of CMMS assets using both IFC, CityGML and Multimedia.

This section explains the technical implementation, the components used, the processing of geometry (e.g., how to extract and transform geometry for each source), and the navigation in the context of an asset. More particularly, the experimentation done focuses on extracting geometry from data sources to standardized geo-referenced geometry while keeping a link with the original data.

The use of standardized streams (WMS and WFS) allow the chosen viewer, UD-Viz, to use various 2D geometry independently from their format. For example :ground photography for background visualization or 2D geometry of cadastral map. UD-Viz is a web-viewer, based on Itowns, a Three.js-based (JS/WebGL) framework for geospatial data visualization. 3D geometries are extracted from their sources and then stored using 3DTiles and served to the viewer with 3D Tiles Samples, a simple NodeJS server. Each 3DTiles from a data source that has additional semantic data must include the link between the geometry and the original data sources. It allows the viewer to query additional information (such as specific attributes or relationships with other objects) about Ifc objects using BIMserver (used only to store semantic data), about CityGML objects using 3DCityDB and about CMMS data using its database.

The viewer will only query the geometry of the objects visible by the camera. It will query 3D geometry from 3D Tiles Samples and 2D geometry from Geoserver using WMS. Using the link embedded in the geometry, the user can then query additional thematic data using either 3DCityDB, BimServer or CarlSource.

4.2 Geometry processing

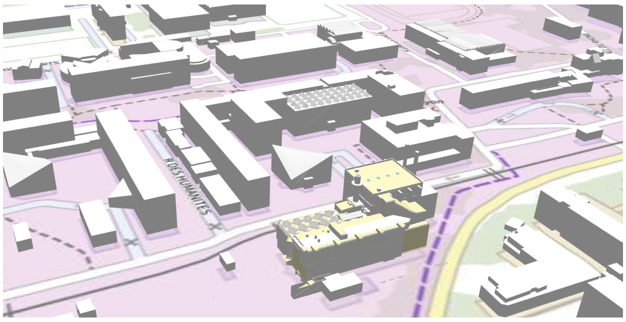

Figure 4. 3D spatial representations : from an Ifc file (in yellow), from CityGML file (in white), stored as 3DTiles.

The link between geometries and their sources can be ensured when using 3DTiles: each tile can contain multiple objects and is stored in the B3DM format. This format specifies how to associate individual semantic properties to objects, stored as GLTF, by using a batch table. In our case, we will use it to store the source and the identifier of the object. Thus, to ensure this link, there is a need to control and understand the creation of 3DTiles from its sources.

Py3DTiles is an open solution created to work with point clouds and manipulate 3DTiles: merge multiple tilesets in one or print a summary of their contents. Following the work of (Jaillot et al., 2020) that proposed an extension to tile CityGML and temporal data, we created other tilers for several data types: .Obj, which can represent CAD or city objects, GeoJSON, that can represent GIS data by extruding 2D polygon (such as the cadastre to create LOD1 cities, less detailed than CityGML), and Ifc, which represent building object, in a tool named Py3DTilers 1. Results of this process are shown on Figure 4 and 6.

As the Ifc and CityGML data describe many objects, we ensure that the objects are split in the 3DTiles as they are in the file, i.e the transformation does not produce a single geometry grouping

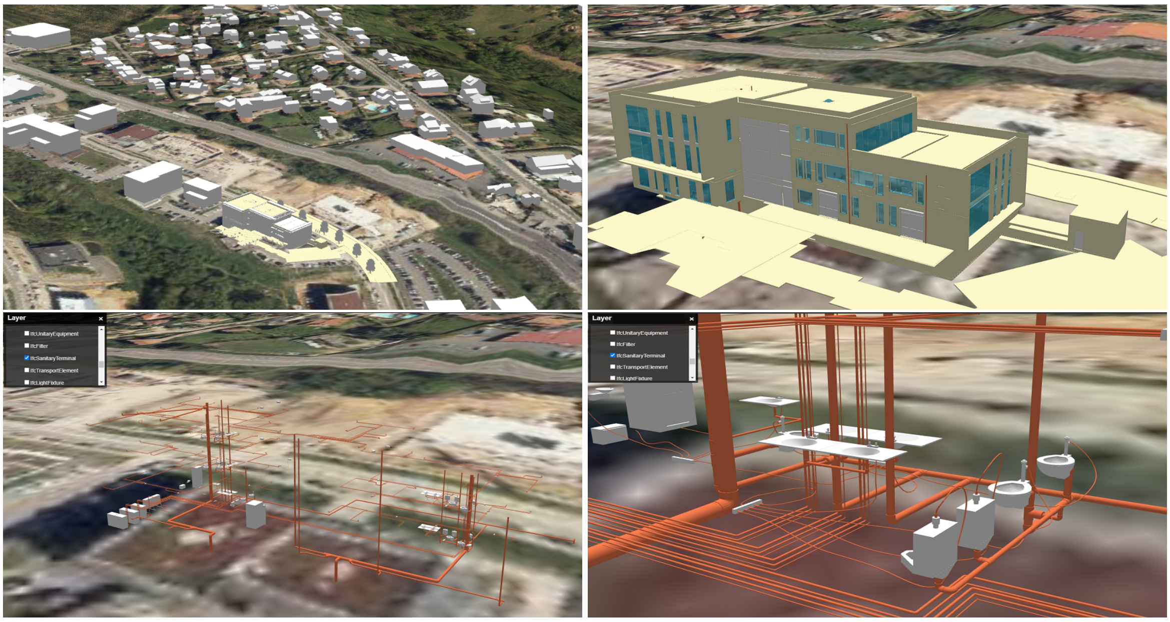

Figure 5. Contextual views of a faucet, using 3D spatial representations of CityGML (in white) and Ifc (colored) data, from a city view (top left) to an object view (bottom right)

all the objects. In addition, the geometry created must include the identifier of the object. To create the geometry from each object of either Ifc or CityGML file, we use two open source solutions, 3DCityDB[7] and IFCOpenShell[8] respectively.

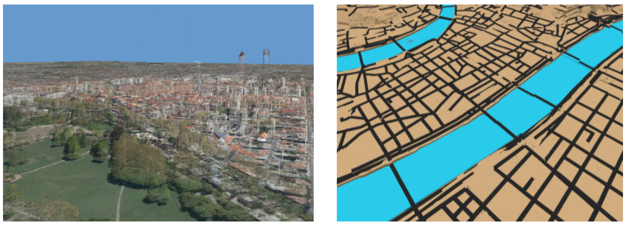

Figure 6. Other available 3D spatial representations : Point clouds (on the left), and from a GeoJSON (the road in black on the right), stored as 3DTiles

4.3 Navigation in the representations of an asset

Spatial 2D and 3D representation and thematic representations, such as linked documents, can be used in our solution to navigate the available information of an asset. Different links between other representations are created to be able to navigate through this information and create contextual views.

An example of navigation in the context of an asset can be seen on the left side of the Figure 7, the hierarchy of a building that contains an asset helps to understand the location of the asset. It is constructed thanks to a component named Ifc Connector. It reads an Ifc file and stores its hierarchy: sites, buildings, storeys, and rooms, and finally the location of assets within this organization. Once those elements are stored, each asset that has an Ifc representation is linked with it, using its GUID (unique Ifc identifier).

As many objects (and their representations) can be displayed on a single view, users can filter objects (and their representations) to only visualize those that are needed. As objects are either organized in a tileset by using their position (for example, CityGML tilesets are created by using a KD-Tree) or by thematic (for example, each tile of an Ifc tileset contains all the objects of one Ifc class), it is possible to visualize an entire 3DTiles tileset but also specific tiles within a tileset. An example of this feature is shown in Figure 7, on the left menu "Layers". To help better understand Ifc objects, they are colored by Ifc classes. This makes it possible to create contextual views using spatial representation of objects and selecting which object to display. In the example given in the Figure 5, we can see that it is possible to visualize the building of a specific faucet, the water network linked to it, or only the faucet. It would also work with electrical networks, by visualizing light fixtures inside a building from an external source.

Documents can also be linked to assets, by extending the work of (Jaillot et al., 2020) with the possibility to link a document to multiple types of ID, either from Ifc or CityGML. It is illustrated in Figure 8, with the possibility to navigate through the spatial and thematic representation of an asset brought by an Ifc file.

4.4 Results

As shown in Figure 4 and 6, our method can handle heterogeneous and complex geospatial data. Those figures demonstrate the capacity to visualize spatial representations from various sources, models, and formats: 3D, with the CityGML of the city of Limonest, and an Ifc file of a building in Limonest; 2D with the background or the roads that are served using WFS by the open data of Lyon; as Point Cloud, still using the open data of Lyon. The use of 3D Tiles allows using the existing methods of viewers that are efficient to load and visualize the geometries as 3D Tiles. It also allows avoiding further development in the viewer to handle geometry described by other data models.

Also, by making loose couplings between used components and using different components for local problems, such as using py3Dtiles to extract the geometry, we ensure that our solution is modular. Such a modular approach allows us to test and use

[7] https://github.com/3dcitydb/3dcitydb; online accessed April 20, 2022
[8] http://ifcopenshell.org/python; online accessed April 20, 2022

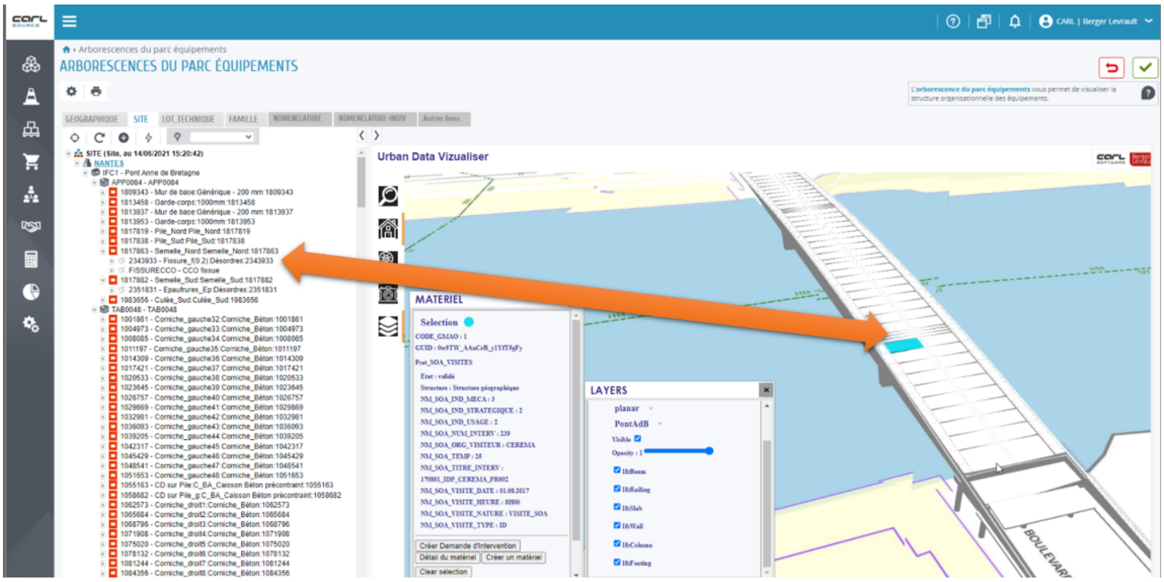

Figure 7. Possible navigation between a spatial representation of a slab in a bridge, from an Ifc file (in blue), and its thematic representation in a CMMS software

various solutions for each problem. Since our work is meant to be used in an existing CMMS software, as shown in Figure 7, a particular effort was made to make our solution **easily reproducible** by using **Docker** and several open-source tools, described in the Table 1. **The demonstration used for Figure 4 can be reproduced**[9] to navigate in representations of buildings of Villeurbanne City, using CityGML file and an Ifc file as sources.

The current solution allows to navigate in an asset's context and create contextual view in different ways. As shown in Figure 7, it is possible to go through 3D visualization and CMMS data. As shown in Figure 8, it is possible to ask for more thematic information about an asset, coming from either the original data source or documents linked to it.

Internal users validated the solution, both from the usage and performance point of view and the feedback obtained was used to modify it. However, the current solution is limited by data quality and quantity issues. Indeed, as BIM and GIS domains are rather new, data produced vary from sources and software used to create them, even when following a specification such as CityGML or Ifc. Also, key information may be missing, such as the projection system used.

5. CONCLUSION

We proposed and implemented a methodology and a logical architecture that allows us to create contextual views of an asset by navigating in information found in heterogeneous geospatial data. We particularly addressed the problem of heterogeneous spatial representation visualization on the Web, thus being able to visualize any geometry that comes from geospatial data. Entire geometry is extracted and then stored using standards to ensure easy use. A link between each spatial representation of an asset and its source is always ensured to be able to navigate through spatial and thematic representations. We also provide a solution to access thematic representation that do not have a spatial one.

Figure 8. Contextual view of a building of a slab constructed using : a spatial representation as 3D geometry in blue from an Ifc file, and thematic information coming from an Ifc file (in frame A), the geometry (in frame B), documents (in frame C)

We presented a technical architecture to make use of this methodology. To make our solution usable for the community, we tried and used as many open-source solutions as possible in this architecture and we give access to a full reproducible demonstration. This solution was tested and approved with internal user. This work is a first step to show that using geospatial data for CMMS can help to better understand assets, by providing 2D or 3D representations and additional semantic data that does not exist in the CMMS world.

Our future works will focus on the following areas: linking an asset and its representations, the creation of symbolic representation for assets that do not have spatial representations, and the improvement of 2D and 3D navigation. To facilitate the navigation in spatial representation, there is a need to identify and link each representation of an asset. For example, a building can have a GIS and a BIM representation that offers either outdoor or indoor geometry. Solutions must be found to identify such representations, for example by using geometrical comparisons. Finally, improving 2D and 3D navigation would imply the creation of different navigation modes. For example,

[9] https://github.com/VCityTeam/UD-Demo-Vcity-Ifc, online accessed April 20, 2022

indoor navigation may need another navigation mode than the current flying one, which is usually used at a city scale, such as from the first-person perspective.

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